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Fuchs, Jr.

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[54] **APPARATUS AND METHOD FOR CONTINUOUS EXTRUSION**

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[21] Appl. No.: **430,984**

Related U.S. Patent Documents

Reissue of:

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Appl. No.: **199,542**
Filed: **Nov. 17, 1971**

[52] **U.S. Cl.** **72/60;** 72/270; 72/284; 226/172

[51] **Int. Cl.**[2] **B21C 33/00**

[58] **Field of Search** 72/60, 45, 270, 42, 72/284, 422, 377; 226/172

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[57] **ABSTRACT**

Four trains of gripping element quadrants are continuously propelled around four endless paths, meeting along one length of travel common to the four paths and cooperating along said common length of travel to form a continuously moving train of centrally apertured gripping elements moving toward an extrusion die adjacent the end of said common length of travel. Rod of indefinite length, coated with shear transmitting medium and extending into the central apertures of the gripping elements, is drawn along the common length of travel by means of shear forces generated in said coating by said gripping elements and transmitted to said rod as viscous drag force along the surface of the rod. Axial and normal stresses are built up in the rod to stress the rod far above its yield strength and increase its ductility, or capacity for deformation without fracture. In this state, the rod is moved through and deformed by the die. A pressure cylinder surrounds the gripping elements along the common length of travel and provides balanced increasing lateral support to the gripping elements as they move toward the die.

97 Claims, 10 Drawing Figures

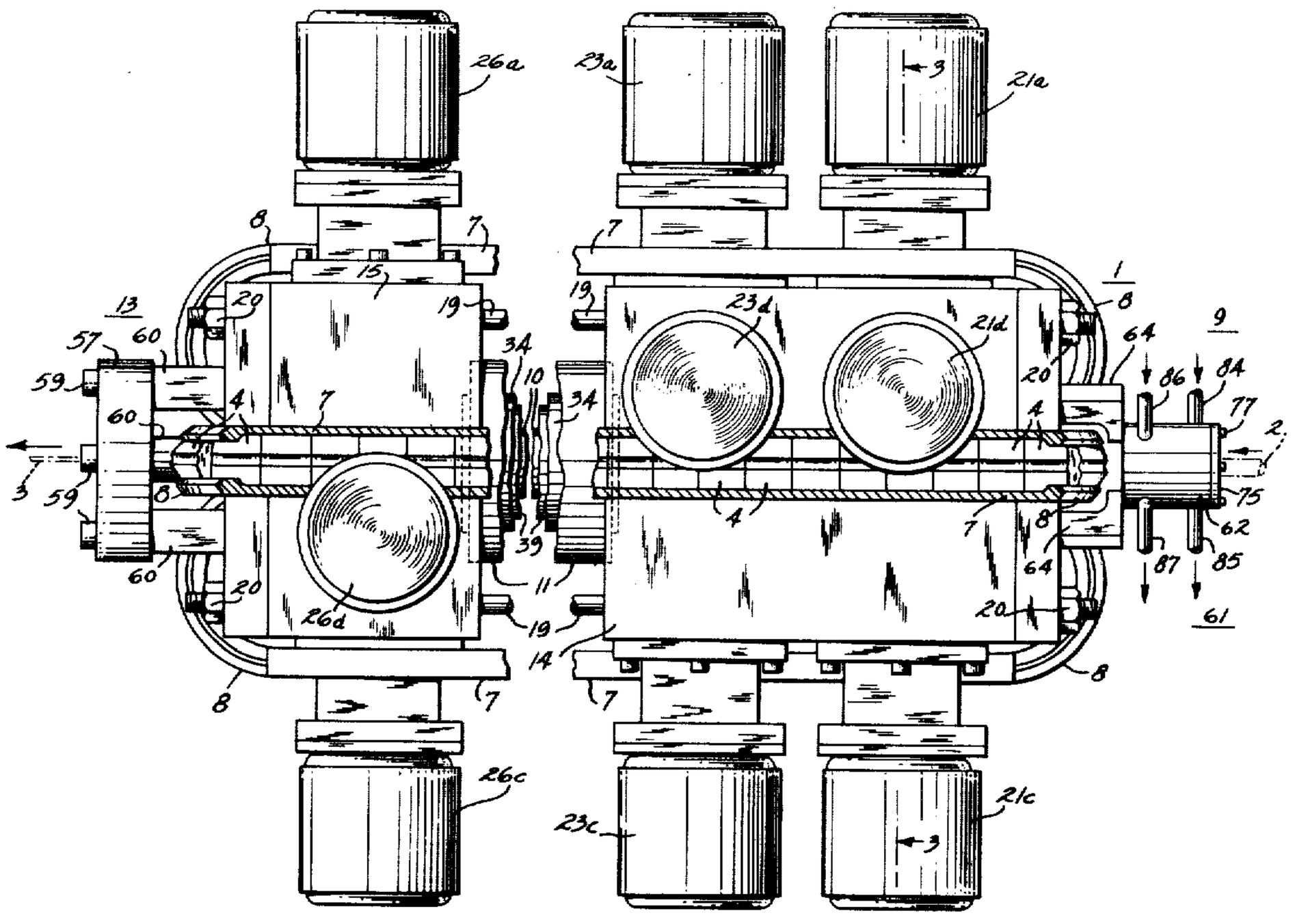

FIG. 1

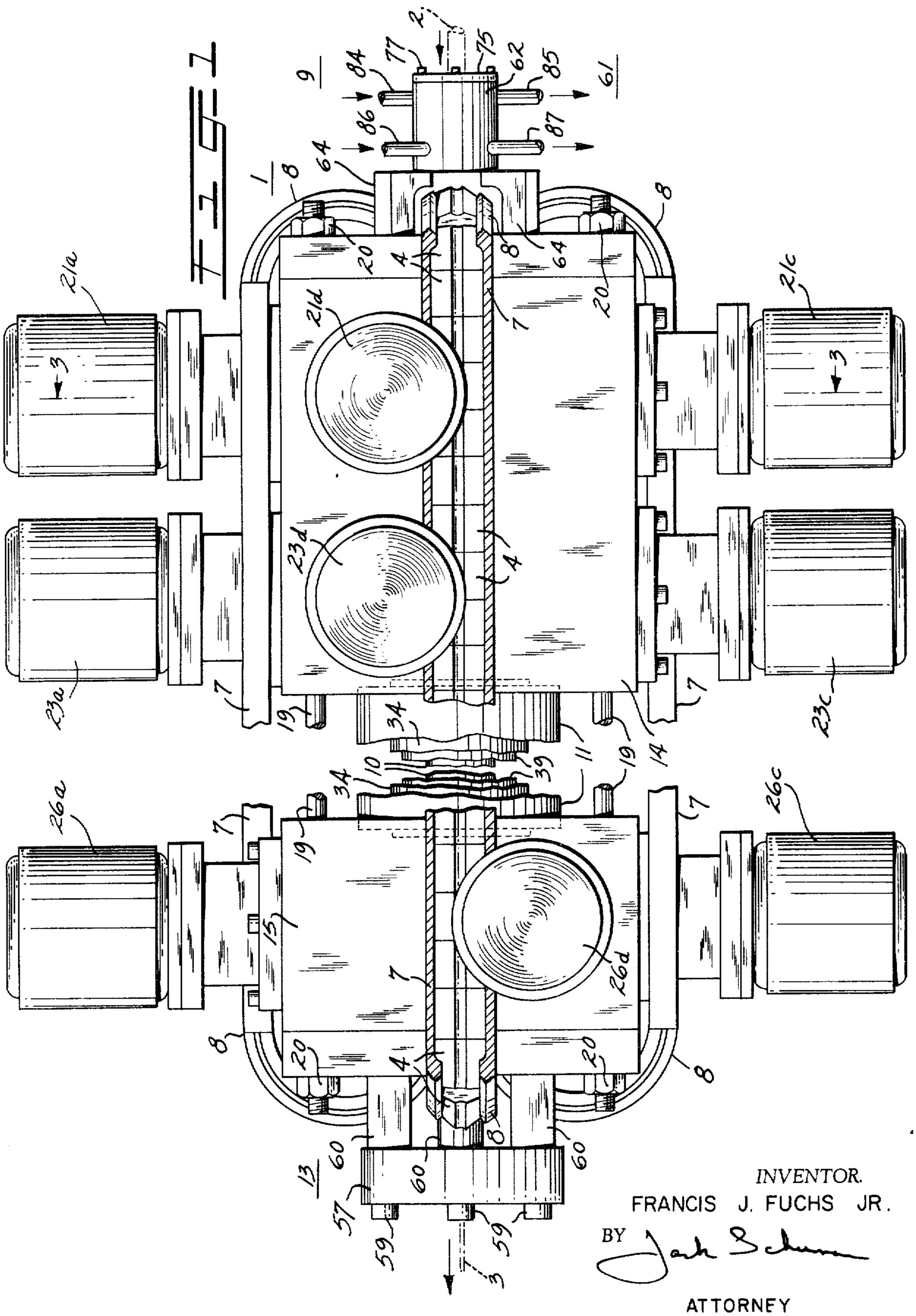

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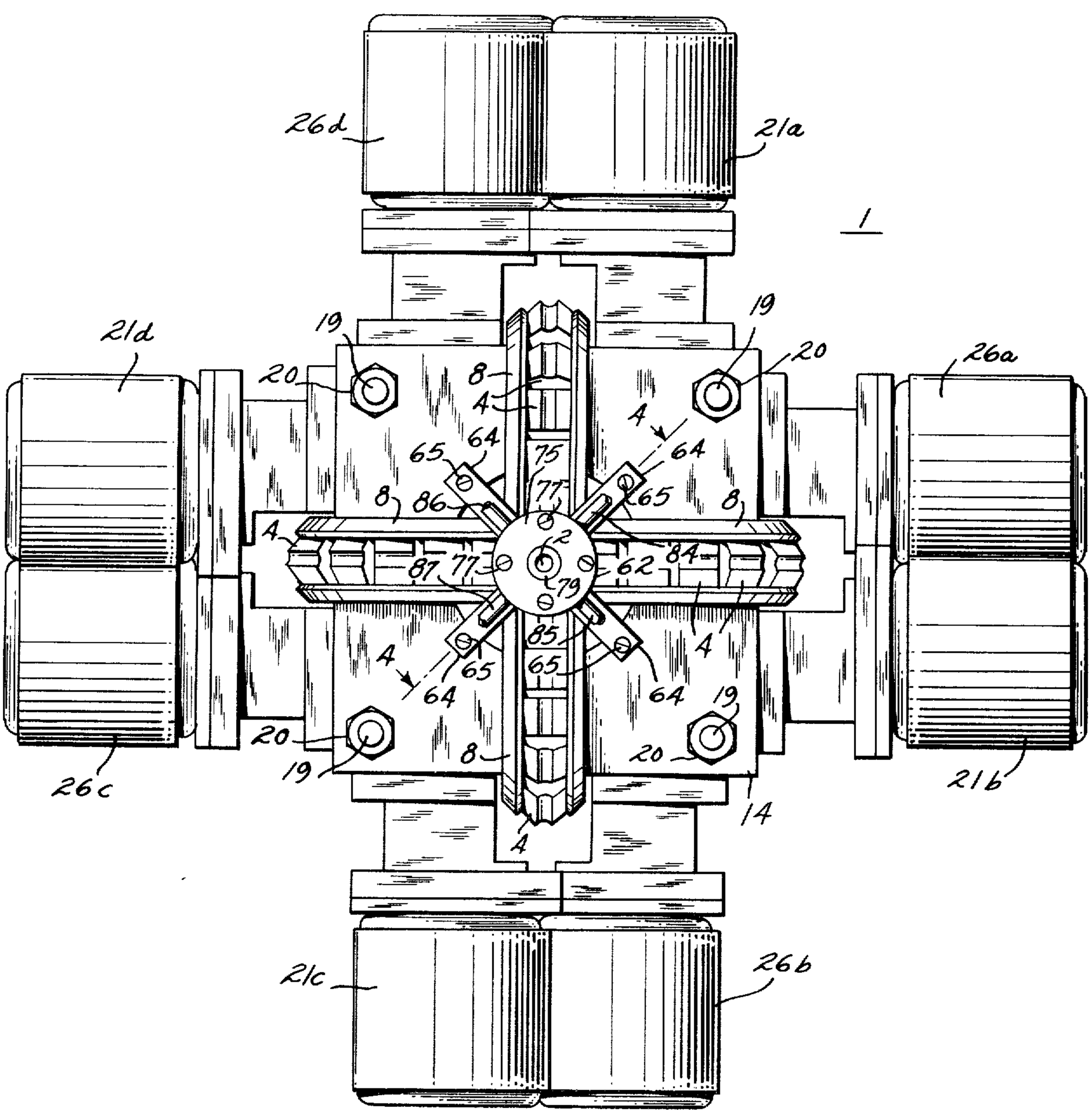
FIG 2



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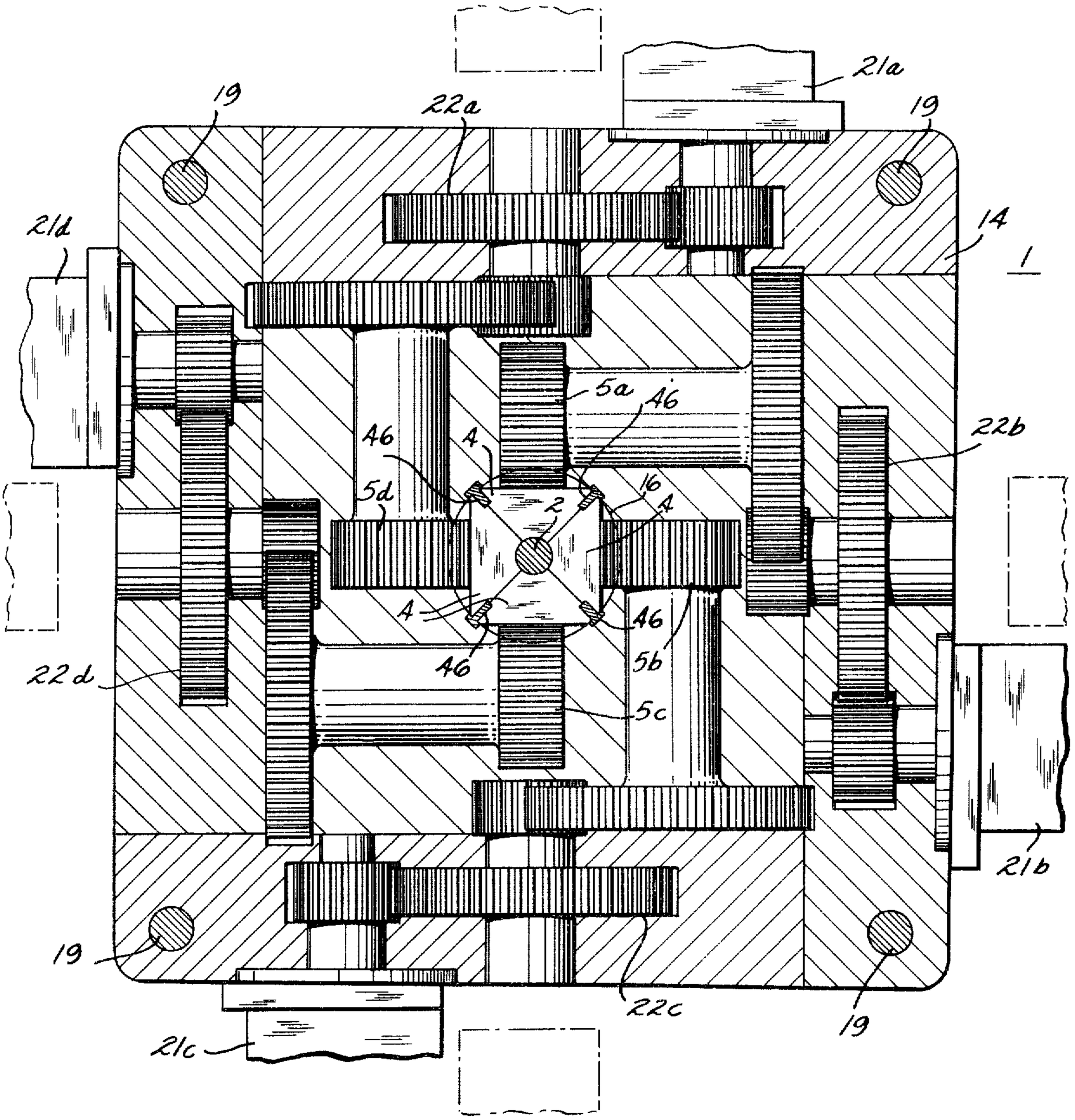

FIG. 3

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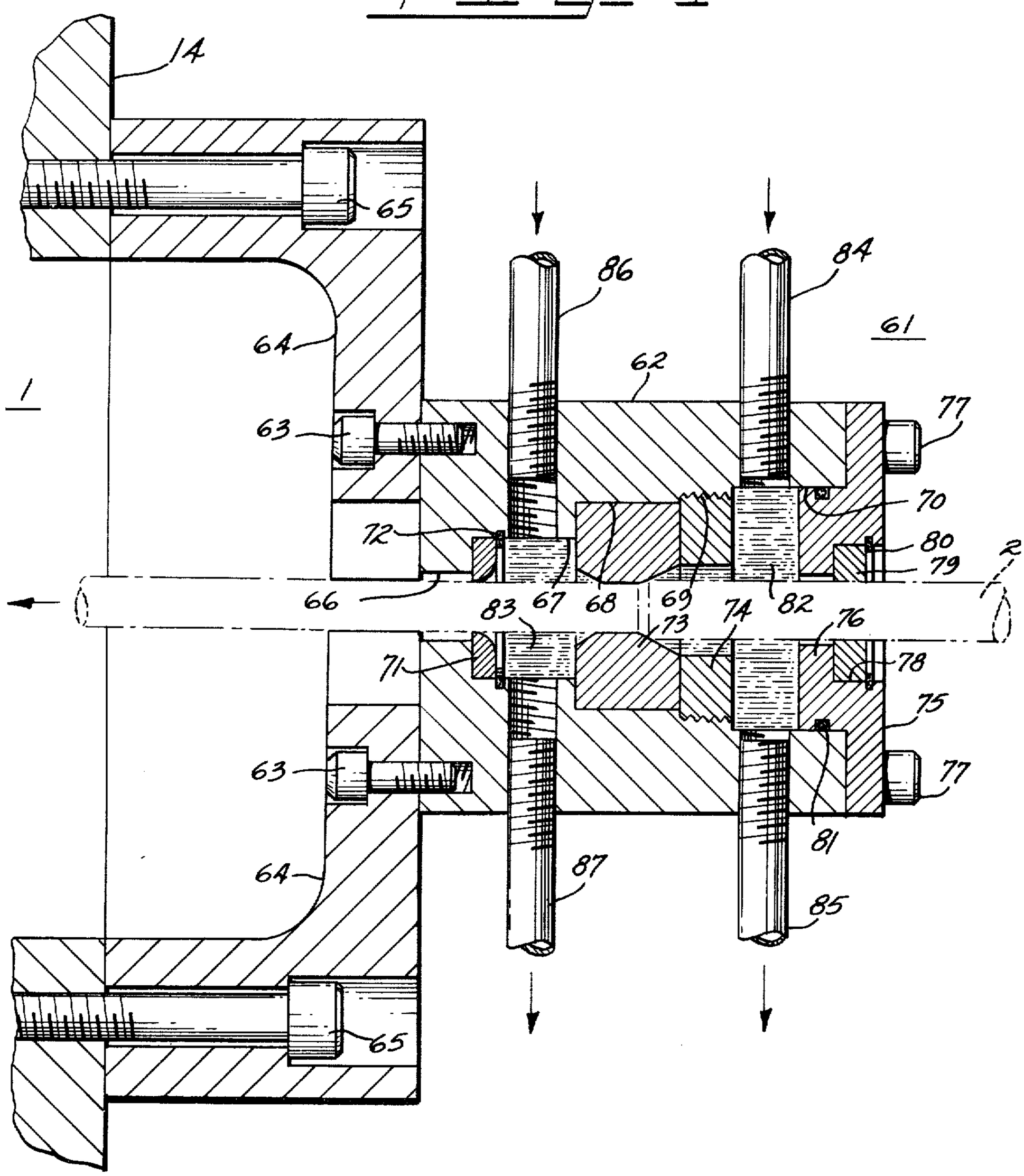
FIG 4



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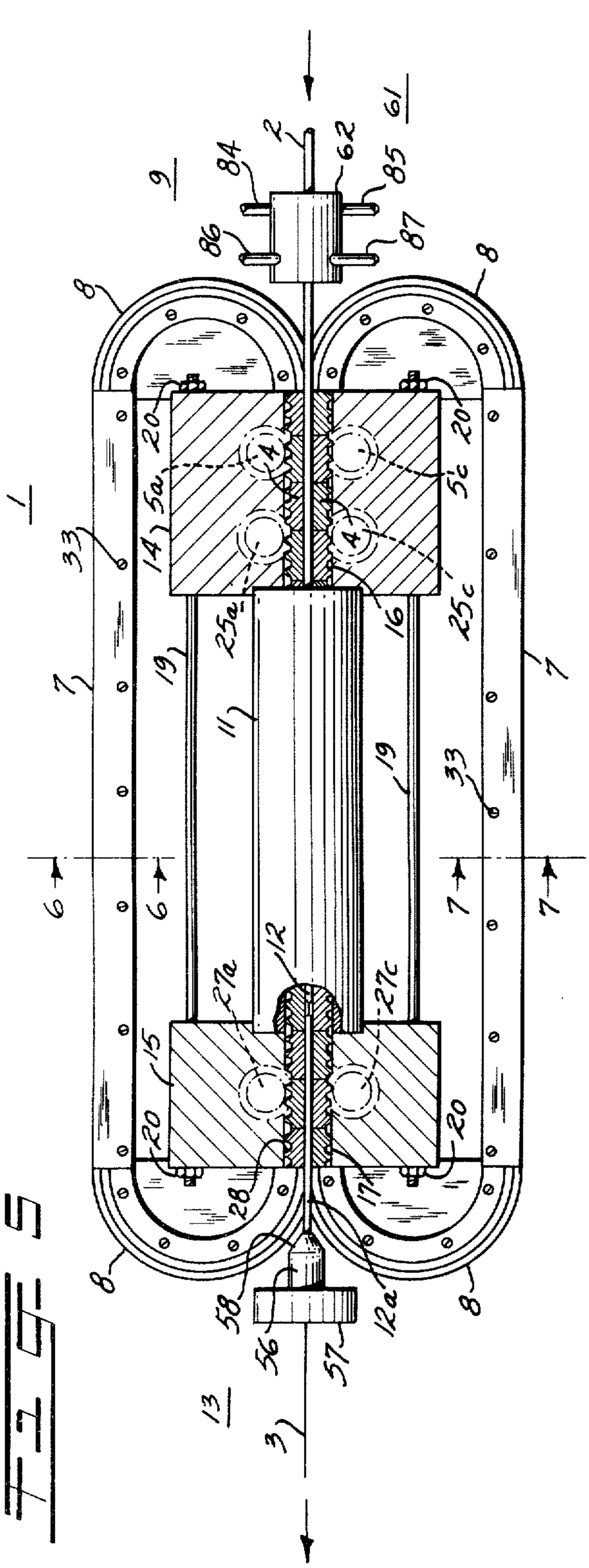

FIG 5

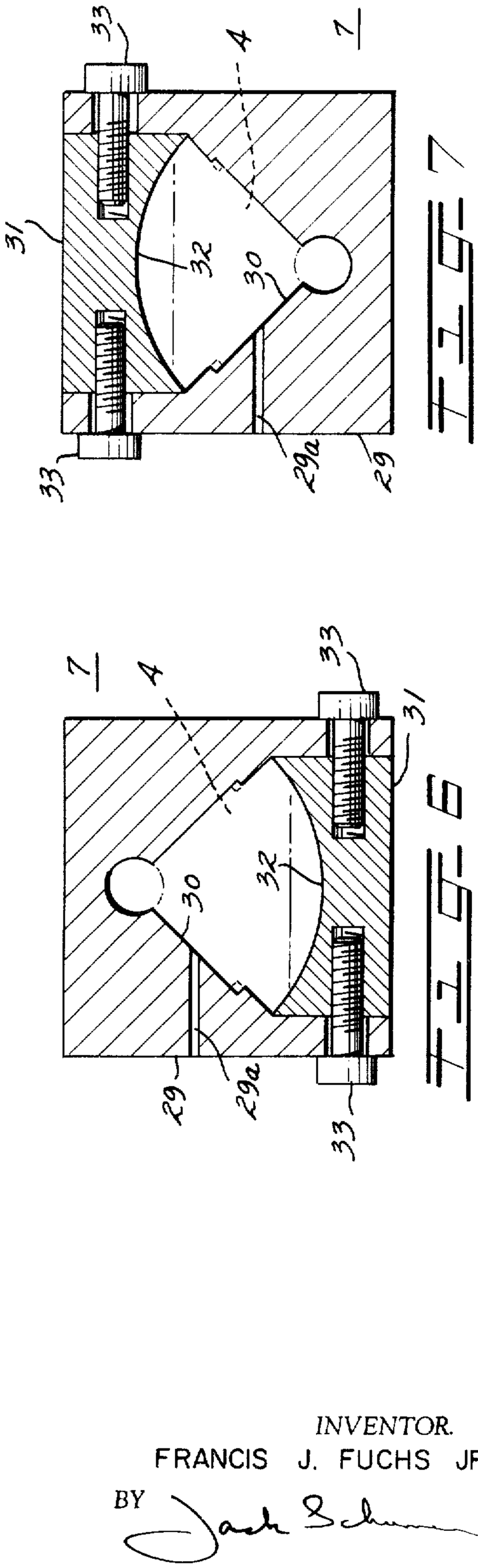

FIG 7

FIG 6

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FIG 8

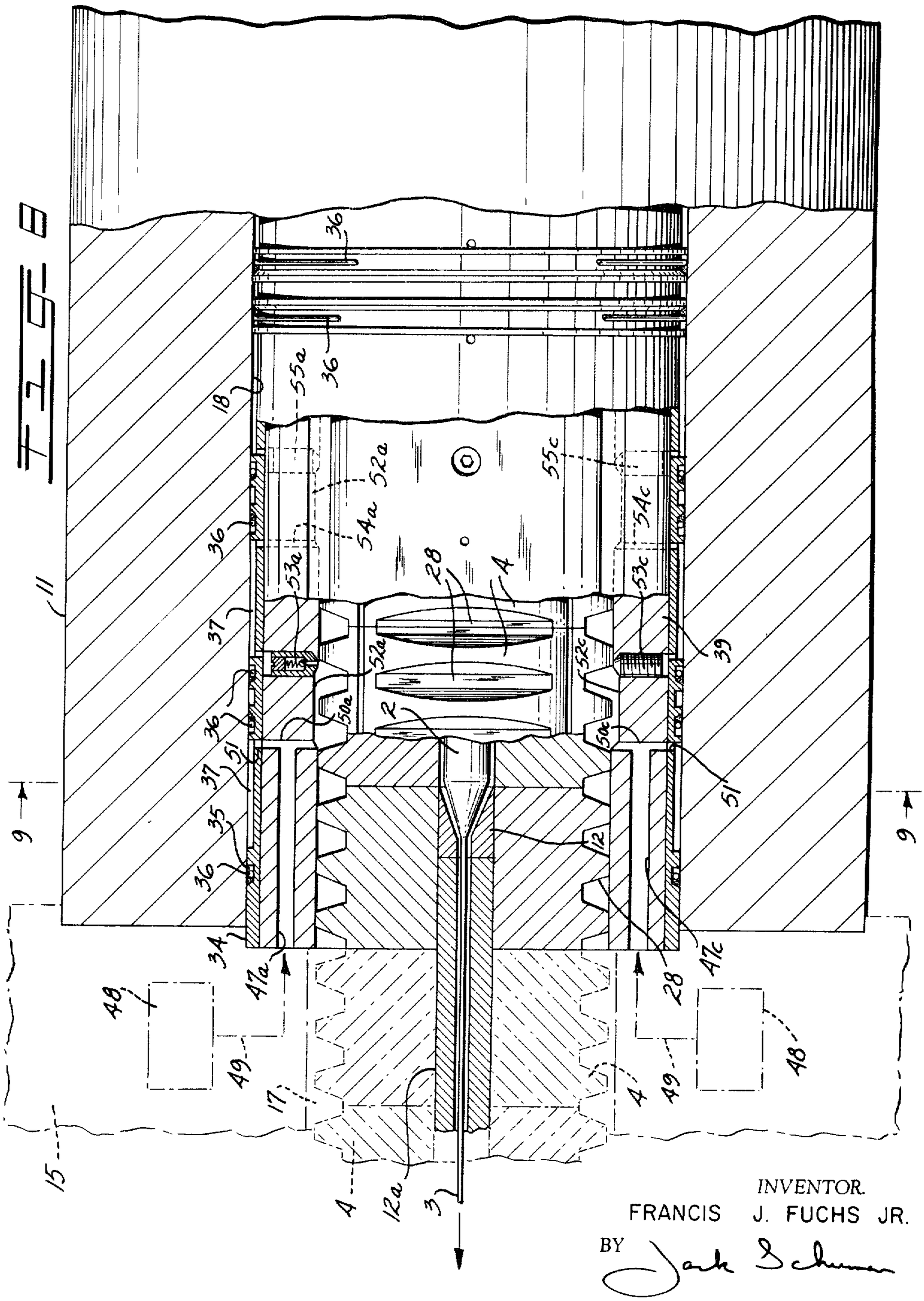

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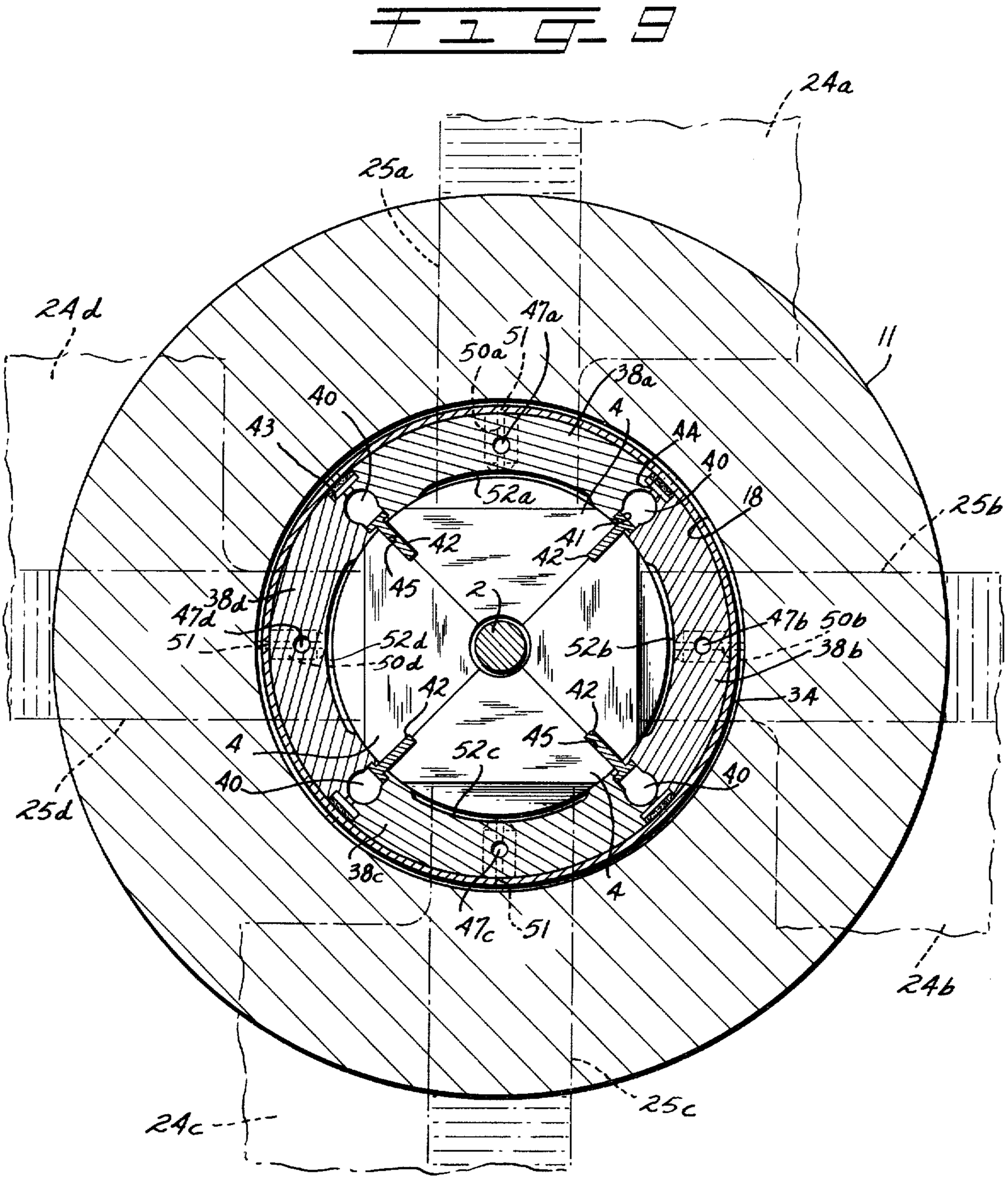
FIG 9



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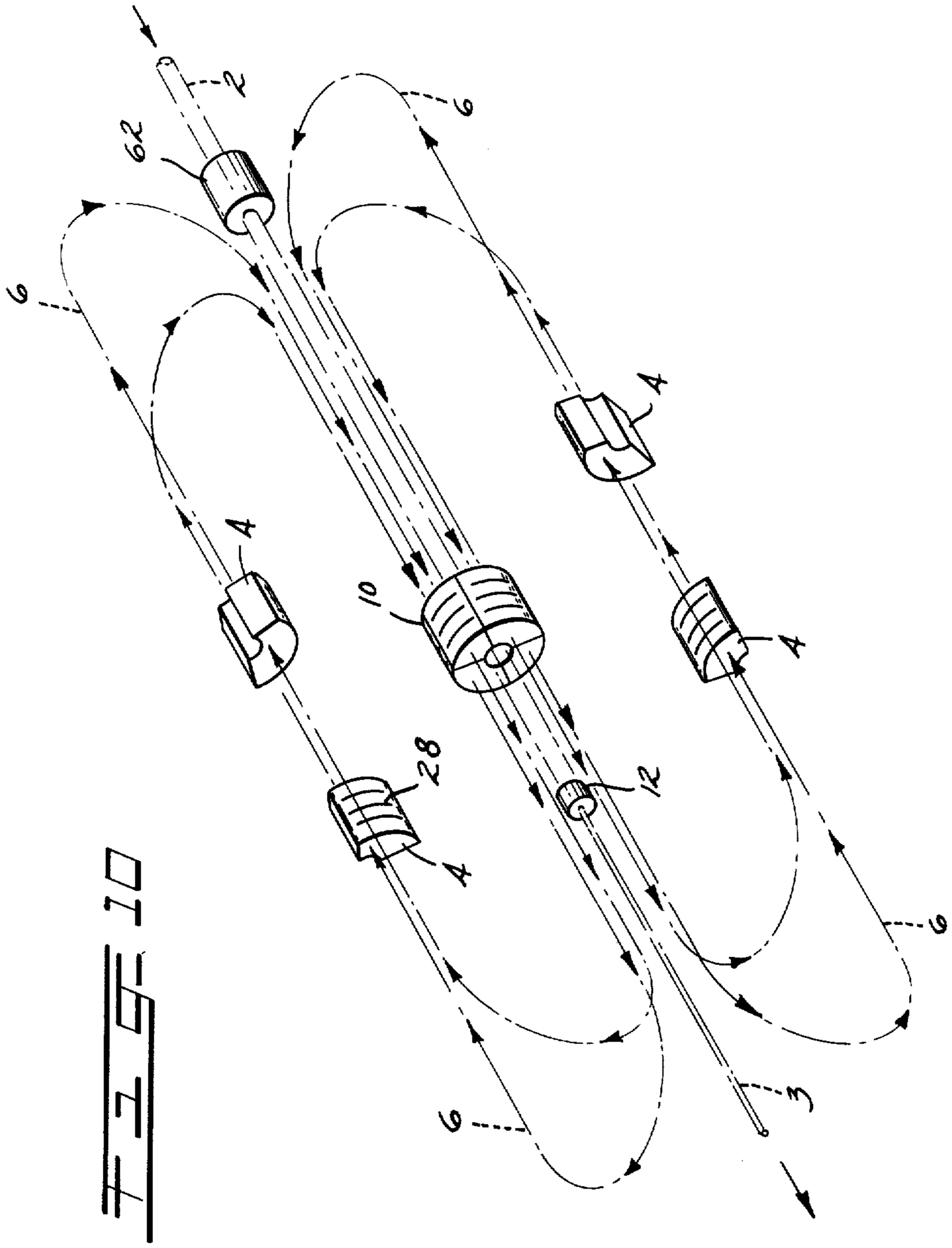

FIG. 10

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APPARATUS AND METHOD FOR CONTINUOUS EXTRUSION

Matter enclosed in heavy brackets [ ] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue.

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates, broadly speaking, to apparatus and method for continuous steady extrusion. More specifically, this invention relates to apparatus and method for continuously applying force along a portion of the surface of a rod of indefinite length to continuously advance the rod through an extrusion die.

2. Description of the Prior Art

Representative are showing the more-or-less continuous deformation of rod appears in the following patents and certificate: U.S. Pat. No. 2,642,280 (1953) to Fisk; U.S. Pat. No. 2,696,907 (1954) to Fisk; U.S. Pat. No. 2,736,425 (1956) to Fisk; U.S. Pat. No. 3,113,676 (1963) to Harkenrider; U.S. Pat. No. 3,415,088 (1968) to Alexander et al.; U.S. Pat. No. 3,417,589 (1968) to Bobrowsky; U.S. Pat. No. 3,423,983 (1969) to Lees et al.; U.S. Pat. No. 3,434,320 (1969) to Green; U.S. Pat. No. 3,440,849 (1969) to Hardy et al.; U.S. Pat. No. 3,449,935 (1969) to McAllan; U.S. Pat. No. 3,526,115 (1970) to Armstrong et al.; U.S.S.R. Author's Certificate 176,229 (1966) to Shvarzburd.

In my copending application Ser. No. 876,940, filed Nov. 14, 1969, and entitled "Apparatus and Method for Continuous Material Feeding and Deformation," there is shown apparatus and method for the continuous steady extrusion of rod of indefinite length, employing the viscous drag force of viscous fluid circuits, portions of which flow along the surface of the rod to build up stresses in the rod and advance the rod through an extrusion die. The disclosure of my copending application, Ser. No. 876,940, represents a milestone in the long history of the art of extrusion as theretofore known.

The present invention represents yet a further improvement in the art of extrusion.

SUMMARY OF THE INVENTION

One of the objects of this invention is to provide improved apparatus and method for the continuous deformation of an elongated workpiece of indefinite length.

Another of the objects of this invention is to provide improved apparatus and method for the continuous and steady extrusion of a rod of indefinite length to produce wire of indefinite length.

A further object of this invention is to provide improved apparatus and method for continuously applying force along a portion of the surface of a rod of indefinite length to build up stresses in the rod and to continuously and steadily advance the rod through an extrusion die.

Still other and further objects of this invention will become apparent during the course of the following description and by reference to the accompanying drawings and the appended claims.

Briefly, I have discovered that the foregoing objects may be attained by providing, in the preferred embodiment, four endless paths, each of said paths guiding a train or series of segments, each segment having gear teeth on the outer surface and having an inner configuration corresponding with the configuration of a quarter of the surface of the rod. Each train or series of segments is driven around its respective path by rotating spur gears, the said paths and their respective series of segments converging about the rod at a station upstream of an extrusion die and diverging at a station downstream of the extrusion die. The segments converged about the rod and being driven from the upstream station toward the downstream station apply a motive force along the surface of a shear transmitting medium which has been applied to the surface of the rod upstream of the upstream station and which shear transmitting medium is interposed between the inner surfaces of the segments and the rod surface, which shear transmitting medium in turn exerts viscous drag force along the surface of the rod to propel the rod through the extrusion die.

BRIEF DESCRIPTION OF THE DRAWING

Referring now to the drawings, in which like numerals represent like parts in the several views:

FIG. **1** represents a longitudinal view in elevation of the apparatus of the present invention, partially broken away to show certain internal features of construction, the rod entering the apparatus at the right being shown in phantom and the wire exiting the machine at the left likewise being shown in phantom;

FIG. **2** represents a transverse view in elevation of the apparatus of the present invention, taken from the right of FIG. **1**;

FIG. **3** represents a transverse section taken along the line **3—3** of FIG. **1**;

FIG. **4** represents a section taken along the line **4—4** of FIG. **2** of a portion of that end of the apparatus through which the rod enters, the rod being shown in phantom;

FIG. **5** represents a longitudinal view, partially in medial section and partially diagrammatic, of the apparatus of the present invention, with all but the last pinions of the several power trains omitted for purposes of simplifying the figure;

FIG. **6** represents a section taken along the line **6—6** of FIG. **5**, showing certain track details;

FIG. **7** represents a section taken along the line **7—7** of FIG. **5**, showing certain track details;

FIG. **8** represents a transverse medial section, partially broken away, of the pressure cylinder, showing the relationship of the extrusion die to the gripping elements closed about the rod;

FIG. **9** represents a transverse section of the pressure cylinder taken along the line **9—9** of FIG. **8**; and

FIG. **10** represents a perspective diagrammatic view of the paths of the four sets of gripping elements relative to the rod and die, and illustrates the broad principle of operation of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Extrusion apparatus **1**, for the continuous and steady extrusion of rod **2** of indefinite (i.e., unrestricted) length to form wire **3** likewise of indefinite (i.e., unrestricted) length is seen, in a broad overview, as comprising four groups or trains of gripping element quad-

rants **4**, the gripping element quadrants **4** of each group or train being driven by a pinion gear **5a, 5b, 5c** and **5d** and by a pinion gear **25a, 25b, 25c** and **25d** around an endless path **6** defined in part by straight lengths **7** of track and curved sections **8** of track. The paths of the four groups or trains of gripping element quadrants **4** converge about rod **2** at the entrance end **9** of the apparatus **1**, four gripping element quadrants **4**, one from each group or train, cooperating to form a gripping element **10** encircling a portion of the surface of rod **2** (e.g., a length of rod **2** corresponding to the length of gripping element **10**) whereby to move, in a manner to be described hereinafter, rod **2** through pressure cylinder **11** and extrusion die **12**, the wire **3** resulting from the extrusion operation appearing at exit end **13** of apparatus **1**, and the cooperating gripping element quadrants **4** diverging past (i.e., downstream of) extrusion die **12** and proceeding thence along their respective separate paths **6**. It will be seen, further, that gripping elements **10** in series between the entrance end **9** and exit end **13** in effect constitute an endless pressure chamber about the length of rod **2** in the apparatus **1**.

Having given this broad overview, the apparatus **1** will now be described in greater detail.

Gear blocks **14** and **15** are provided with central bores **16** and **17**, respectively, and are counterbored slightly in their facing sides to receive the ends of pressure cylinder **11** having a central bore **18**. Gear blocks **14** and **15** and pressure cylinder **11** are securely held in assembled relation, with the longitudinal axes of bores **16, 17** and **18** aligned by means of tie rods **19** extending completely through the said gear blocks **14** and **15** and tensioned by means of nuts **20** threaded on the ends of the said tie rods **19** sufficiently to bear on the far sides of gear blocks **14** and **15**, as shown in FIG. **1**.

Mounted to gear block **14**, around that portion of gear block **14** adjacent the entrance end **9** of apparatus **1**, are four fluid motors **21a, 21b, 21c** and **21d** preferably driven in unison from a common supply of pressurized motive fluid (not shown). Fluid motors **21a, 21b, 21c** and **21d** are arranged about the four faces of gear block **14** so as to occupy positions 90° removed from each other, when the apparatus **1** is viewed from an end thereof. Each fluid motor **21a, 21b, 21c** and **21d** drives a gear train **22a, 22b, 22c** and **22d**, respectively, suitably mounted and arranged within gear block **14** as shown in FIG. **3**, and each gear train **22a, 22b, 22c** and **22d** drives a pinion gear **5a, 5b, 5c** and **5d**, the teeth of which extend into central bore **16** at positions 90° removed from each other as shown in FIG. **3**. Mounted to gear block **14**, around that portion of gear block **14** adjacent pressure cylinder **11**, are four fluid motors **23a, 23b, 23c** and **23d**, preferably driven in unison from a common supply of pressurized fluid (not shown). Fluid motors **23a, 23b, 23c** and **23d** are arranged about the four faces of gear block **14** so as to occupy positions 90° removed from each other, when the apparatus **1** is viewed from an end thereof. Each fluid motor **23a, 23b, 23c** and **23d** drives a gear train **24a, 24b, 24c** and **24d**, respectively, suitably mounted and arranged within gear block **14**, in a manner similar to the mounting and arrangement of gear trains **22a, 22b, 22c** and **22d** shown in FIG. **3**. Each gear train **24a, 24b, 24c** and **24d** drives a pinion gear **25a, 25b, 25c** and **25d**, the teeth of which extend into central bore **16** at positions 90° removed from each other.

Mounted to gear block **15** are four fluid pumps **26a, 26b, 26c** and **26d**. Fluid pumps **26a, 26b, 26c** and **26d** are arranged about the four faces of gear block **15** so as to occupy positions 90° removed from each other, when the apparatus **1** is viewed from an end thereof. Each fluid pump **26a, 26b, 26c** and **26d** is driven by a gear train (not shown) suitably mounted and arranged within gear block **15** in a manner similar to the mounting and arrangement of gear trains **22a, 22b, 22c** and **22d** shown in FIG. **3**, each said gear train being driven by a pinion gear **27a, 27b, 27c** and **27d**, the teeth of which extend into central bore **17** at positions 90° removed from each other.

It is the function of pinion gears **5a, 5b, 5c** and **5d**, and of pinion gears **25a, 25b, 25c** and **25d**, engaging the teeth of and driving gripping element quadrants **4** in the groups or trains thereof upstream from pressure cylinder **11**, when operated, preferably in unison, by supplying their respective fluid motors **21a, 21b, 21c** and **21d**, and their respective fluid motors **23a, 23b, 23c** and **23d** with pressurized fluid from the source (not shown), to advance the said trains of gripping element quadrants **4** through the pressure cylinder **11** from the inlet or upstream end thereof toward the exit or downstream end thereof and thence around the several endless paths **6**.

It is the function of pinion gears **27a, 27b, 27c** and **27d**, engaging and being driven by the teeth of advancing gripping element quadrants **4** in the groups or trains thereof downstream from pressure cylinder **11**, to act as brakes on the said moving trains of gripping element quadrants, working against pinions **5a, 5b, 5c** and **5d**, and against pinions **25a, 25b, 25c** and **25d**, and thereby hold together, in rigid juxtaposition within pressure cylinder **11** between the inlet and exit ends thereof, all gripping element quadrants **4** in the same group or train.

Conveniently, the intakes of fluid pumps **26a, 26b, 26c** and **26d** may be connected by conduits (not shown) to the respective discharge ports of fluid motors **23a, 23b, 23c** and **23d**, and the discharge ports of fluid pumps **26a, 26b, 26c** and **26d** may be connected by suitable conduits (not shown) to the source of pressurized fluid serving fluid motors **21a, 21b, 21c, 21d, 23a, 23b, 23c** and **23d**. In this manner, the work of operating fluid pumps **26a, 26b, 26c** and **26d** to pump fluid therethrough will effect the desired braking action on the gripping element guadrants **4** within pressure cylinder **11**.

It will be seen that four curved sections **8** of track are arranged at positions 90° removed from each other, when the apparatus is viewed transversely, at the exit end of central bore **17** of gear block **15**, and that four curved sections **8** of track are arranged at positions 90° removed from each other, when the apparatus is viewed transversely at the inlet end of central bore **16** of gear block **14**, and that the ends of said curved sections **8** of track at opposite ends of apparatus **1** are joined by straight sections **7** of track. Tracks **7**, as shown in cross-section, particularly in FIGS. **6** and **7**, comprise body portion **29** with quadrant-shaped longitudinal opening **30** receiving gripping element quadrants **4**, retainer portion **31** having curved inner face **32** corresponding with the curved toothed exterior surface of gripping element quadrants **4**, and threaded bolts **33** holding retainer portion **31** in place in body portion **29**. Tracks **8** are of generally similar construction, receiving gripping element quadrants **4** and providing for a

smooth transition in the paths **6** between straight sections **7** of track and central bores **16** and **17** of gear blocks **14** and **15.**

Advantageously, gripping element guadrants **4** from the separate endless paths **6,** which have met in that length of travel common to the said four endless paths **6** and therein constitute gripping elements **10,** are maintained in closely abutting relation prior to and as they are engaged by pinions **5a, 5b, 5c** and **5d,** whereby to insure that they are properly engaged by the teeth of said pinions **5a, 5b, 5c** and **5d** and pass through pressure cylinder **11** without gaps therebetween. To compensate for the curved track sections **8** which, due to the configuration of gripping element quadrants **4,** may cause gaps between adjacent gripping element quadrants **4** in certain portions of their respective endless paths **6,** means are provided in each endless path **6** to urge the gripping element quadrants **4** in closely abutting relation, toward pinions **5a, 5b, 5c** and **5d.** Such means may, for example, comprise a transverse passage **29a** in track **7** of each endless path **6,** for the introduction of pressurized air between adjacent gripping element quadrants **4,** thereby urging the gripping element quadrants **4,** as they pass downstream of the conduit **29a** against the train of gripping element quadrants **4** leading to pinions **5a, 5b, 5c** and **5d.**

Mounted within central bore **18** of pressure cylinder **11** is a sleeve **34** (FIG. **8**) having an outer diameter such as to permit sleeve **34** to fit snugly within the said central bore **18.** Sleeve **34** is somewhat longer than pressure cylinder **11** and projects from both ends thereof into the counterbores in the facing sides of gear blocks **14** and **15.**

The outer surface of sleeve **34** is undercut or reduced in diameter at spaced lengths therealong, as shown in FIG. **8,** thereby to provide spaced pairs of seal seats **35** receiving sealing rings **36** except at the ends of sleeve **34** where only single seal seats **35** with sealing rings **36** are provided, and further to provide between the spaced pairs of seal seats **35** (and between the endmost pairs of seal seats **35** and the single seal seats **35** adjacent thereto) annular compartments **37.** The center-to-center distance between spaced pairs of seal seats **35** (and between the endmost pairs of seal seats **35** and the single seal seats **35** adjacent thereto) is, in the preferred embodiment, equal to the length of a gripping element quadrant **4.**

Four sleeve quadrants **38a, 38b, 38c** and **38d,** each occupying 90° of arc, are positioned within sleeve **34** and collectively constitute a second sleeve **39** of outer diameter substantially equal to the inner diameter of sleeve **34** (i.e., the second sleeve **39** closely fits within sleeve **34**) and of length equal to the length of sleeve **34.** The sides of sleeve quadrants **38a, 38b, 38c** and **38d** are recessed so as to provide, when the sleeve quadrants **38a, 38b, 38c** and **38d** are assembled, a longitudinal circular recess **40** adapted to receive an elongated heating element (not shown), a seat **41** adapted to receive guide member **42,** and a seat **43** adapted to receive a sealing plate **44.** It will be noted, from FIG. **9,** that guide members **42** extend inwardly of sleeve **39** and are 90° removed from each other. Gripping element quadrants **4** are each provided, on the outer portions of their mating faces, with a slot **45,** and guide members **42,** extending into the slots **45** between engaged gripping element quadrants **4,** as shown in FIG. **9,** function to key the gripping element **10** constituted by the said gripping element quadrants **4** to prevent the same from rotating in passing longitudinally through pressure cylinder **11.**

It will be noted that, as each gripping element quadrant **4** passes along that portion of its path **6** defined by tracks **7** and **8,** the cross-section of tracks **7** and **8** prevent the gripping element quadrant **4** from rotating transversely to its direction of movement. Means are provided to key the gripping element quadrants **4** as they leave curved tracks **8** and enter central bore **16** of gear block **14** at the entrance end **9** of the apparatus **1.** Means are also provided to key the gripping element quadrants **4** as they leave central bore **17** of gear block **15** and enter curved tracks **8** at the exit end **13** of apparatus **1.** Such means comprises guide members **46** arranged and secured in radially spaced relation to each other (i.e., at 90° angles to each other) inside central bores **16** and **17** of gear blocks **14** and **15,** respectively. Corresponding guide members **46** in central bores **16** and **17** are aligned with each other and with corresponding guide members **42** in pressure cylinder **11,** and are suitably oriented with respect to curved tracks **8** so that, as the gripping element quadrants **4** leave curved tracks **8** at the entrance end **9** of apparatus **1,** guide members **46** in central bore **16** will register with slots **45** in adjacent gripping element quadrants **4;** further, as gripping element quadrants **4** leave central bore **17** to enter curved tracks **8** at the exit end **13** of apparatus **1,** slots **45** between adjacent gripping element quadrants **4** will clear guide members **46** and the individual gripping element quadrants **4** will enter their respective curved tracks **8** smoothly.

In the foregoing manner, gripping element quadrants **4** are guided around the entire length of their respective endless path **6** (i.e., through track **7,** track **8,** central bore **16,** pressure cylinder **11,** central bore **17,** track **8** and back to track **7**).

Fluid passageways **47a, 47b, 47c** and **47d** are formed through the ends of sleeve quadrants **38a, 38b, 38c** and **38d,** respectively, midway between the sides thereof, and communicate with sources of pressurized fluid indicated diagrammatically by the numeral **48** through conduit **49.** Fluid passageways **47a, 47b, 47c** and **47d** communicate, at their innermost ends with radial passageways **50a, 50b, 50c** and **50d,** respectively. The outer ends of radial passageways **50a, 50b, 50c** and **50d** communicate, through apertures **51** in sleeve **34,** with endmost compartment **37,** thereby to pressurize said endmost compartment **37** uniformly thereabout. This pressure is exerted, through sleeve **34** on sleeve quadrants **38a, 38b, 38c** and **38d** and thence on their respective gripping element guadrants **4,** thereby forcing said gripping element quadrants inwardly and tightly about die **12** and die stem **12a.**

The inner surfaces of sleeve quadrants **38a, 38b, 38c** and **38d,** opposite each of the pairs of sealing rings **36** and between guide members **42,** are recessed at **52a, 52b, 52c** and **52d,** to provide a fluid passageway between said inner surfaces and teeth **28** of gripping element quadrants **4.** Elsewhere, there is a close sliding fit between the inner surfaces of sleeve quadrants **38a, 38b, 38c** and **38d** and teeth **28.**

The inner ends of radial passageways **50a, 50b, 50c** and **50d** communicate with adjacent recesses **52a, 52b, 52c** and **52d** thereby to introduce pressurized fluid therein, adjacent the downstream (relative to the direction of movement of gripping element quadrants **4**) sides of said adjacent recesses **52a, 52b, 52c** and **52d.** Thus, the pressurized fluid acting upon the external

surfaces of gripping element quadrants **4**, forces said gripping element quadrants **4** inwardly and tightly about rod **2** immediately upstream of die **12**.

Adjacent the upstream (relative to the direction of movement of gripping element quadrants **4**) sides of said last mentioned recesses **52a, 52b, 52c** and **52d** are provided pressure reducing valves **53a, 53b, 53c** and **53d**, communicating between said last mentioned recesses **52a, 52b, 52c** and **52d** and the next compartment **37**. Pressure reducing valves **53a, 53b, 53c** and **53d** are adapted to vent pressurized fluid from said last mentioned recesses **52a, 52b, 52c** and **52d**, when the pressure of the fluid therein rises above a predetermined value, to said next compartment **37** at a lower pressure and thereby maintain a predetermined difference in pressure between the higher-pressurized last mentioned recesses **52a, 52b, 52c** and **52d** and the lower-pressurized next compartment **37**.

Radial passageways **54a, 54b, 54c** and **54d** communicate between the upstream side of the last mentioned compartment **37** and the downstream sides of the next recesses **52a, 52b, 52c** and **52d**, thereby introducing pressurized fluid from said compartment **37** to said recesses **52a, 52b, 52c** and **52d**. Because of pressure reducing valves **53a, 53b, 53c** and **53d**, the pressure in said recesses **52a, 52b, 52c** and **52d** against the exterior surfaces of gripping element quadrants **4** is less than the pressure against the exterior surfaces of those gripping element quadrants **4** immediately downstream.

Pressure reducing valves **55a, 55b, 55c** and **55d** communicate between the upstream sides of said last-mentioned recesses **52a, 52b, 52c** and **52d** and the next compartment **37**, and are adapted to vent pressurized fluid from said recesses **52a, 52b, 52c** and **52d**, when the pressure of the fluid therein rises above a predetermined value, to said next compartment **37** at a lower pressure and thereby maintain a predetermined difference in pressure between the said higher-pressurized recesses **52a, 52b, 52c** and **52d** and the lower-pressurized next compartment **37**. Pressure reducing valves **55a, 55b, 55c** and **55d** are operative to pass pressurized fluid therethrough at a lower pressure than pressure reducing valves **53a, 53b, 53c** and **53d**, and therefore the pressure against the exterior surfaces of gripping element quadrants **4** passing by the recesses **52a, 52b, 52c** and **52d** associated with the said pressure reducing valves **55a, 55b, 55c** and **55d** is less than against the exterior surfaces of those gripping element quadrants immediately downstream.

The same arrangement of radial passageways and pressure reducing valves is provided for all the compartments **37** and recesses **52a, 52b, 52c** and **52d** upstream of those just described (i.e., to the right of FIG. **8**). The pressure reducing valves are operative to pass pressurized fluid therethrough at lower levels than the immediately downstream pressure reducing valves. In this manner, the exterior surfaces of gripping element quadrants **4** are subjected to a pressure gradient increasing in steps from the time the gripping element quadrants **4** enter the upstream end of pressure cylinder **11** (i.e., the right end thereof as viewed in FIG. **8**) until at least the time the gripping element quadrants **4** pass over die **12**.

Pressurized fluid from the upstream-endmost compartment **37** may be fed back to a suitable pump (not shown) for subsequent recycling to the sources **48** of pressurized fluid.

Die stem **12a** extends downstream of gear block **15**, past the point at which gripping element quadrants **4** enter their respective curved tracks **8** as they leave central bore **17**, and extends through die stem support **56** into a counterbore in support plate **57**. Die stem support **56**, secured to support plate **57**, has a tapered nose **58** permitting it to extend closely between the diverging curved tracks **8** (FIG. **5**) and thereby give effective lateral support to die stem **12a**. Bolts **59**, extending through support plate **57** and spacers **60**, are threaded into the downstream side of gear block **15**. In this manner, die **12** is securely supported against the thrust of rod **2**.

Apparatus **61** for sizing and coating rod **2** with a shear transmitting medium before the said rod **2** enters apparatus **1** is seen as comprising housing **62** secured by means of threaded bolts **63** to radially spaced brackets **64** which, in turn, are secured to the upstream side of gear block **14** by means of threaded bolts **65**. The longitudinal axis of housing **62** registers with the longitudinal axes of central bores **16** and **17** and of pressure cylinder **11**. Housing **62** is provided with a first bore **66**, a second larger bore **67**, a third yet larger bore **68**, a threaded section **69** and a fourth yet larger bore **70**. Scraper **71** is positioned at the downstream side of bore **67**, adjacent bore **66**, and is secured in position by means of retainer ring **72**. A sizing die **73** is mounted within bore **68**, and is secured in position by means of threaded retaining ring **74** screwed into threaded section **69**. A cover plate **75** having a projecting central portion **76** extending partially into bore **70** is secured to the upstream side of housing **62** by means of threaded bolts **77**. Cover plate **75** is provided with counterbore **78** in which is mounted scraper **79** secured in position by means of retainer ring **80**. Ring seal **81** is provided around projecting central portion **76** of cover plate **75**.

It will be seen, in FIG. **4**, that there is a space in bore **70**, between threaded retaining ring **74** and projecting central portion **76**. This space constitutes a first coating chamber **82**.

It will also be seen, in FIG. **4**, that there is a space in bore **67**, between scraper **71** and sizing die **73**. This space constitutes a second coating chamber **83**.

Feed conduit **84** communicates between a source (not shown) of shear transmitting medium and first coating chamber **82**, thereby to supply said first coating chamber **82** with shear transmitting medium. Drain conduit **85** is provided to withdraw excess shear transmitting medium from first coating chamber **82**, and, through a suitable conduit (not shown), the withdrawn shear transmitting medium may be recycled to the source.

Feed conduit **86** communicates between a source (not shown) of shear transmitting medium and second coating chamber **83**, thereby to supply said second coating chamber **83** with shear transmitting medium. Drain conduit **87** is provided to withdraw excess shear transmitting medium from second coating chamber **83** and, through a suitable conduit (not shown), the withdrawn shear transmitting medium may be recycled to the source.

The shear transmitting medium which may be utilized in practicing the present invention will desirably have a high viscosity and shear strength, be capable of lubricating die **12**, provide good wetting action on the rod **2**, and have minimal viscosity variation with respect to pressure, temperature and shearing rate. Such a medium may otherwise be known as viscous fluid, and

examples of such a suitable medium are beeswax and polyethylene wax.

It is known in the art that many metals and other materials increase in ductility, or have an increased capacity for deformation without fracture, when they are subjected to high pressure. This effect is known as the "Bridgman effect," and the principle is treated in "Large Plastic Flow and Fracture" by P. W. Bridgman, published by McGraw Hill (New York, 1952). The present invention is particularly adapted to subject rod **2** to such high pressures. For example, when rod **2** is of aluminum, apparatus **1** is designed so that pressure on rod **2** adjacent die **12** will be approximately 150,000 psi, and where rod **2** is of copper, apparatus **1** is designed so that pressure on the rod **2** adjacent die **12** will be approximately 250,000 psi. These pressures are far above the respective yield strengths of aluminum and copper, and will increase the ductility, or capacity for deformation without fracture, of these materials.

The operation of the present invention will now be described.

Rod **2** is fed from a source of supply (not shown) through apparatus **61.** In passing through scraper **79,** dirt and the like are removed from the surface of rod **2.** In passing through first coating chamber **82,** the surface of rod **2** is provided with a coating of shear transmitting medium which medium, beeswax in the preferred embodiment, is capable of lubricating a die. In passing through sizing die **73,** the diameter of rod **2** is sized to a uniform value. In passing through second coating chamber **83,** the surface of rod **2** is recoated with shear transmitting medium. In passing through scraper **71,** shear transmitting medium in excess of the desired thickness of coating thereof on the surface of rod **2** is removed. Thereafter, coated rod **2** enters the entrance end **9** of apparatus **1.**

Fluid motors **21a–21d** and **23a–23d** are operated, whereby gripping element quadrants **4** are propelled around their respective endless paths **6,** each gripping element quadrant **4** cooperating with a gripping element quadrant **4** from each of the other trains thereof as they enter central bore **16** of gear block **14** until they leave central bore **17** of gear block **15** to form a gripping element **10.** Thus, there is a constantly moving continuous train of gripping elements **10** being propelled from the entrance end **9** to the exit end **13** of apparatus **1.**

As coated rod **2** enters the entrance end **9** of apparatus **1** (i.e., the upstream end of central bore **16**), a gripping element **10** closely contacts the entire perimetric surface of a length of shear transmitting medium coating on the surface of rod **2,** which length corresponds to the length of the said gripping element **10.** In being propelled toward the exit end **13** of apparatus **1,** the gripping element **10** provides a motive force along the surface of the shear transmitting medium and thereby produces a shear force in the shear transmitting medium, which shear force is applied along the said perimetric surface of rod **2** as a friction or viscous drag force, directed toward the exit end **13** of apparatus **1,** which friction or viscous drag force tends to propel rod **2** toward the said exit end. The cumulative effort of the several gripping elements **10** producing such friction or viscous drag force along the perimetric surface of rod **2** results in a longitudinal or axial compressive stress gradient in the rod **2,** which gradient increases from the entrance end **9** toward the die **12.** At the same time, inasmuch as there is no passageway

along the exterior surface of die **12** for the flow of shear transmitting medium (i.e., all of the coating of viscous shear transmitting medium on the surface of rod **2** must pass through die **12** along with rod **2**), the pressure in the coating of shear transmitting medium upstream of die **12** accumulates from the entrance end **9** toward the die **12.** In other words a pressure gradient is established in the coating of shear transmitting medium which gradient increases from the entrance end **9** toward die **12.** It will be apparent, to those familiar with this are, that normal stress in rod **2** is a function of the pressure in the shear transmitting medium, and therefore rod **2** experiences normal stress increasing from said entrance end **9** to said die **12.** Apparatus **1** is designed to operate in such a manner that the difference between axial stress and normal stress in rod **2** upstream of die **12** does not exceed the yield strength of the rod material.

Gripping element quadrants **4** constituting gripping elements **10** are supported against, and thereby contain, the pressure in the shear transmitting medium coating on rod **2.** From the entrance end **9** of apparatus **1** downstream to the downstream side of gear block **14,** lateral support required to be given to the gripping element quadrants **4** is normal, and this is provided by the wall of central bore **16,** gripping element quadrants **4** being able to be moved readily through said central bore **16.** Downstream of gear block **14,** the pressure in the shear transmitting medium has risen to the point that substantial lateral support to gripping element quadrants **4** is required, which lateral support requirements will increase in the direction of die **12.** It is the function of pressure cylinder **11** to supply this increasing lateral support to the gripping element quadrants in the manner hereinbefore described. It will be noted that the lateral support pressures obtained in pressure cylinder **11** are designed to balance the outward thrusts on gripping element quadrants **4** developed by the increasing pressures in the shear transmitting medium and are related to the axial stresses developed in rod **2** in such a manner that (1) sufficient lateral support is given to gripping element quadrants **4** so that at all points along pressure cylinder **11,** the normal stress in rod **2** never falls to such a value that the rod axial stress exceeds the rod normal stress by an amount exceeding the yield strength of the rod material (as otherwise the rod **2** would be caused to bulge out or mushroom) and (2) excessive support pressures on gripping element quadrants **4,** particularly in the upstream section of pressure cylinder **4** are never produced (as otherwise this may crush gripping element quadrants **4** against rod **2**).

In the preferred mode of operation, rod **2** as it advances within pressure cylinder **11** toward die **12** is stressed in compression far above its yield strength to the range at which it exhibits increased ductility, or has an increased capacity for deformation without fracture. In such a state, rod **2** passes into die **12,** along with the coating of shear transmitting medium, and is deformed to produce wire **3.**

From the foregoing description, it will be clear that I have invented novel apparatus and method for continuously deforming a workpiece (e.g., rod) of indefinite length to produce a production (e.g., wire) of indefinite length.

What I claim is:

1. Method of continuously deforming an elongated workpiece of indefinite length to produce an elongated

product of indefinite length, said method comprising:

a. continuously moving a train of gripping elements around an endless path, said path including a first station upstream of a deforming agency and a second station downstream of said deforming agency, the direction of travel of said train around said endless path being from said first station toward said second station;

b. placing said moving train of gripping elements between said first station and said deforming agency in continuous operative engagement with the elongated surface of said elongated workpiece thereby to continuously apply motive force along the elongated surface of said elongated workpiece in the direction of said deforming agency;

c. continuously advancing said elongated workpiece *against said deforming agency* by means of said motive force [against said deforming agency] to produce elongated product.

2. Method [as in claim **1**, further comprising:

d. during the performance of step (b),] *for continuously deforming an elongated workpiece of indefinite length to produce an elongated product of indefinite length, said method comprising:*

a. continuously moving a train of gripping elements around an endless path, said path including a first station upstream of a deforming agency and a second station downstream of said deforming agency, the direction of travel of said train around said endless path being from said first station toward said second station;

b. placing said moving train of gripping elements between said first station and said deforming agency in continuous operative engagement with the elongated surface of said elongated workpiece thereby to continuously apply motive force along the elongated surface of said elongated workpiece in the direction of said deforming agency; while simultaneously

c. cumulating same motive force from said first station toward said deforming agency whereby to produce [an axial] *a compressive* stress gradient within said elongated workpiece increasing from said first station toward said deforming [agency] *agency; and*

d. continuously advancing said elongated workpiece against said deforming agency by means of said motive force to produce elongated product.

3. Method [as in claim **1**, further comprising:

d. simultaneously with step (b),] *for continuously deforming an elongated workpiece of indefinite length to produce an elongated product of indefinite length, said method comprising:*

a. continuously moving a train of gripping elements around an endless path, said path including a first station upstream of a deforming agency and a second station downstream of said deforming agency, the direction of travel of said train around said endless path being from said first station toward said second station;

b. placing said moving train of gripping elements between said first station and said deforming agency in continuous operative engagement with the elongated surface of said elongated workpiece thereby to continuously apply motive force along the elongated surface of said elongated workpiece in the direction of said deforming agency; while simultaneously

c. continuously applying pressure on those surfaces of said gripping elements remote from the elongated surface of said elongated workpiece between said first station and said deforming agency whereby to maintain normal stress in said elongated workpiece of magnitude such that the difference between axial stress and normal stress in said elongated workpiece at any point between said first station and the entrance to said deforming agency does not exceed the yield strength of the workpiece [material.] *material; and*

d. continuously advancing said elongated workpiece against said deforming agency by means of said motive force to produce elongated product.

4. Method as in claim **2**, further comprising:

e. simultaneously with steps (b) and [(d)] *(c)*, continuously applying a pressure gradient on those surfaces of said gripping elements remote from the elongated surface of said elongated workpiece between said first station and said deforming agency, said pressure gradient increasing said first station toward said deforming agency, whereby to maintain a normal stress gradient in said elongated workpiece increasing from said first station toward said deforming agency and of magnitude suchc that at any point between said first station and the entrance to said deforming agency the difference between axial stress and normal stress in said elongated workpiece does not exceed the yield strength of the workpiece material.

5. Method for continuously deforming an elongated workpiece of indefinite length to produce an elongated product of indefinite length, said method comprising:

a. continuously advancing an endless chamber from a first station upstream of a deforming agency to a second station downstream of said deforming agency,

b. placing the interior of said endless chamber in continuous operative engagement with the entire perimeter of said elongated workpiece between said first station and said deforming agency thereby to continuously apply motive force along said entire perimeter in the direction of said deforming agency,

c. continuously advancing said elongated workpiece *against said deforming agency* by means of said motive force [against said deforming agency] to produce elongated product.

6. Method as [in claim **5**, further comprising:

d. during the performance of step (b),] *for continuously deforming an elongated workpiece of indefinite length to produce an elongated product of indefinite length, said method comprising:*

a. continuously advancing an endless chamber from a first station upstream of a deforming agency to a second station downstream of said deforming agency,

b. placing the interior of said endless chamber in continuous operative engagement with the entire perimeter of said elongated workpiece between said first station and said deforming agency thereby to continously apply motive force along said entire perimeter in the direction of said deforming agency, while simultaneously

c. cumulating said motive force from said first station toward said deforming agency whereby to produce [an axial] *a compressive* stress gradient within said elongated workpiece increasing from said first station toward said deforming [agency.] *agency; and*

d. continuously advancing said elongated workpiece against said deforming agency by means of said motive force to produce elongated product.

7. Method [as in claim **5,** further comprising:

d. simultaneously with step (b),] *for continuously deforming an elongated workpiece of indefinite length to produce an elongated product of indefinite length, said method comprising:*

a. continuously advancing an endless chamber from a first station upstream of a deforming agency to a second station downstream of said deforming agency,

b. placing the interior of said endless chamber in continuous operative engagement with the entire perimeter of said elongated workpiece between said first station and said deforming agency thereby to continuously apply motive force along said entire perimeter in the direction of said deforming agency, while simultaneously

c. continuously applying external pressure on and around the entire perimeter of said endless chamber from said first station to said deforming agency, said external pressure having sufficient magnitude to maintain normal stress in the elongated workpiece of magnitude such that the difference between axial stress and normal stress in the elongated workpiece at any point between said first station and the entrance to said deforming agency does not exceed the yield strength of the workpiece [material.] *material; and*

d. continuously advancing said elongated workpiece against said deforming agency by means of said motive force to produce elongated product.

8. Method as in claim **6,** further comprising:

e. simultaneously with steps (b) and (c), continuously applying an external pressure gradient between said first station and said deforming agency on and around the entire perimeter of said endless chamber increasing from said first station toward said deforming agency, said external pressure gradient maintaining a normal stress gradient in said elongated workpiece increasing from said first station toward said deforming agency and of magnitude such that at any point between said first station and the entrance to said deforming agency the difference between axial stress and normal stress in the elongated workpiece does not exceed the yield strength of the workpiece material.

9. Method as in claim **5,** further comprising:

d. performing step (a) by:

i. providing a plurality of trains of gripping elements;

ii. continuously moving each of said plurality of trains of gripping elements around an endless path, whereby to provide a plurality of endless paths of gripping elements, said first station and said second station and the span therebetween being common to all of said plurality of endless paths;

iii. cooperatively associating gripping elements in each of said plurality of trains at said first station to form said endless chamber and continuing said cooperation as said plurality of trains moves along said span toward said second station.

10. Method as in claim **5,** further comprising:

d. performing step (a) by:

i. providing a plurality of trains of gripping elements;

ii. continuously moving each of said plurality of trains of gripping elements around an endless path, whereby to provide a plurality of endless paths of gripping elements, said first station and said second station and the span therebetween being common to all of said plurality of endless paths;

iii. cooperatively associating gripping elements in each of said plurality of trains at said first station to form said endless chamber and continuing said cooperation as said plurality of trains moves along said span toward said second station;

iv. discontinuing the said cooperation of said gripping elements at said second station.

11. Method for continuously deforming an elongated workpiece to produce an elongated product, said method comprising:

a. applying a coating of shear transmitting medium to the elongated surface of said elongated workpiece,

b. continuously applying motive force in the direction of a deforming agency along that surface of said coating of shear transmitting medium remote from the elongated surface of said elongated workpiece, thereby to exert drag force along the elongated surface of said elongated workpiece in the direction of said deforming agency;

c. continuously advancing said elongated workpiece by means of said drag force against said deforming agency to produce an elongated product.

12. Method as in claim **11,** wherein:

d. said coating of shear transmitting medium is applied to the entire perimeter of the elongated surface of said elongated workpiece.

13. Method as in claim **12,** wherein:

e. said motive force is applied around the entire perimeter of the surface of said shear transmitting medium.

14. Method as in claim **11,** wherein:

d. said motive force is applied to said surface of said shear transmitting medium from a first station upstream of said deforming agency,

e. said coating of shear transmitting medium is continuously applied around the entire perimeter of the elongated surface of said elongated workpiece at a second station upstream of said first station as said elongated workpiece moves past said second station toward said first station.

15. Method as in claim **14,** wherein:

f. said motive force is applied around the entire perimeter of the surface of said shear transmitting medium.

16. Method as in claim **11,** wherein:

d. said shear transmitting medium is a viscous fluid.

17. Method as in claim **16,** wherein:

e. said viscous fluid is beeswax.

18. Method as in claim **16,** wherein:

e. said viscous fluid is polyethylene wax.

19. Method as in claim **11,** wherein:

d. said motive force is applied to said surface of said shear transmitting medium from a station upstream of said deforming agency toward said deforming agency; said method further comprising:

e. simultaneously with step (b), continuously applying pressure on that surface of said coating of shear transmitting medium remote from the elongated surface of said elongated workpiece between said station and said deforming agency, thereby to maintain normal stress in said elongated workpiece

of magnitude such that at any point between the entrance to said deforming agency and said station the difference between axial stress and normal stress in said elongated workpiece does not exceed the yield strength of the workpiece material.

20. Method for continuously deforming an elongated workpiece to produce an elongated product, said method comprising:

a. applying a coating of shear transmitting medium to the elongated surface of said elongated workpiece;

b. continuously applying motive force in the direction of a deforming agency from a station upstream of said deforming agency along that surface of said coating of shear transmitting medium remote from the elongated surface of said elongated workpiece and cumulating said motive force from said station toward said deforming agency, thereby to exert drag force along the elongated surface of said elongated workpiece in the direction of said deforming agency, said drag force increasing in magnitude from said station toward said deforming agency, and producing [an axial] *a compressive* stress gradient in said elongated workpiece increasing from said station toward said deforming agency;

c. continuously advancing said elongated workpiece by means of said drag force against said deforming agency to produce an elongated product.

21. Method as in claim **20,** wherein:

d. said coating of shear transmitting medium is applied to the entire perimeter of the elongated surface of said elongated workpiece.

22. Method as in claim **21,** wherein:

e. said motive force is applied around the entire perimeter of the surface of said shear transmitting medium.

23. Method as in claim **20,** wherein:

d. said coating of shear transmitting medium is continuously applied around the entire perimeter of the elongated surface of said elongated workpiece at a second station upstream of said first mentioned station as said elongated workpiece moves past said second station toward said first mentioned station.

24. Method as in claim **23,** wherein:

e. said motive force is applied around the entire perimeter of the surface of said shear transmitting medium.

25. Method as in claim **20,** wherein:

d. said shear transmitting medium is a viscous fluid.

26. Method as in claim **25,** wherein:

e. said viscous fluid is beeswax.

27. Method as in claim **25,** wherein:

e. said viscous fluid is polyethylene wax.

28. Method as in claim **20,** further comprising:

d. simultaneously with step (b), continuously applying pressure between said first mentioned station and said deforming agency on that surface of said coating of shear transmitting medium remote from the elongated surface of said elongated workpiece, said pressure increasing in magnitude from said first mentioned station toward said deforming agency, thereby to maintain normal stress in said elongated workpiece increasing in magnitude from said first mentioned station toward said deforming agency, the difference in magnitude between said axial stress and normal stress in said elongated workpiece at any point upstream of the entrance to said deforming agency not exceeding the yield strength of the workpiece material.

29. Method for continuously deforming an elongated workpiece of indefinite length to produce an elongated product of indefinite length, said method comprising:

a. applying a coating of shear transmitting medium to the entire perimeter of the elongated surface of said elongated workpiece;

b. continuously advancing from a first station upstream of a deforming agency to a second station downstream of said deforming agency an endless chamber encircling and in contact with that surface of said coating of shear transmitting medium remote from the elongated surface of said elongated workpiece thereby to apply motive force in the direction of said deforming agency along said surface of said coating and cumulating said force from said first station toward said deforming agency, whereby to exert drag force along the elongated surface of said elongated workpiece in the direction of said deforming agency, said drag force increasing in magnitude from said first station toward said deforming agency and producing [an axial] *a compressive* stress gradient in said elongated workpiece increasing from said first station toward said deforming agency;

c. continuously advancing said elongated workpiece by means of said drag force against said deforming agency to produce an elongated product.

30. Method as in claim **29,** wherein:

d. said coating of shear transmitting medium is continuously applied around the entire perimeter of the elongated surface of said elongated workpiece at a third station upstream of said first station as said elongated workpiece moves past said third station toward said first station.

31. Method as in claim **29,** wherein:

d. said shear transmitting medium is a viscous fluid.

32. Method as in claim **31,** wherein:

e. said viscous fluid is beeswax.

33. Method as in claim **31,** wherein:

e. said viscous fluid is polyethylene wax.

34. Method as in claim **29,** further comprising:

d. continuously applying external pressure on and around the entire perimeter of said endless chamber from said first station to said deforming agency, said external pressure having sufficient magnitude to maintain normal stress in the elongated workpiece of magnitude such that the difference between axial stress and normal stress in the elongated workpiece at any point between said first station and the entrance to said deforming agency does not exceed the yield strength of the workpiece material.

35. Method as in claim **29,** further comprising:

d. continuously applying an external pressure gradient between said first station and said deforming agency on and around the entire perimeter of said endless chamber increasing from said first station toward said deforming agency, said external pressure gradient maintaining a normal stress gradient in said elongated workpiece increasing from said first station toward said deforming agency and of magnitude such that at any point between said first station and the entrance to said deforming agency the difference between axial stress and normal stress in the elongated workpiece does not exceed the yield strength of the workpiece material.

36. Apparatus for continuously deforming an elongated workpiece of indefinite length to produce an

elongated product of indefinite length, said apparatus comprising:

a. a deforming agency;

b. a train of gripping elements;

c. first means providing an endless path for said train of gripping elements, said path including a first station upstream of said deforming agency and a second station downstream of said deforming agency;

d. second means for continuously moving said train of gripping elements around said endless path, the direction of travel of said train of gripping elements being from said first station toward said second station;

e. third means for *continuously advancing said elongated workpiece against said deforming agency to produce elongated product, said third means comprising means for* placing said moving train of gripping elements between said first station and said deforming agency in continuous operative engagement with the elongated surface of said elongated workpiece, thereby to continuously apply motive force along the elongated surface of said elongated workpiece in the direction of said deforming [agency and continuously advance said elongated workpiece against said deforming agency to produce elongated product.] *agency.*

37. Apparatus [as in claim **36,** wherein:

f. said apparatus is adapted to cumulate] *for continuously deforming an elongated workpiece of indefinite length to produce an elongated product of indefinite length, said apparatus comprising:*

a. a deforming agency;

b. a train of gripping elements;

c. frist means providing an endless path for said train of gripping elements, said path including a first station upstream of said deforming agency and a second station downstream of said deforming agency;

d. second means for continuously moving said train of gripping elements around said endless path, the direction of travel of said train of gripping elements being from said first station toward said second station;

e. third means for continuously advancing said elongated workpiece against said deforming agency to produce elongated product, said third means comprising means for placing said moving train of gripping elements between said first station and said deforming agency in continuous operative engagement with the elongated surface of said elongated workpiece, thereby to continuously apply motive force along the elongated surface of said elongated workpiece in the direction of said deforming agency, said third means further comprising means for cumulating motive force from said first station toward said deforming agency whereby to produce [an axial] *a compressive* stress gradient within said elongated workpiece increasing from said first station toward said deforming agency.

38. [Apparatus as in claim **36,** wherein:

f. said third means is adapted to continuously apply] *Apparatus for continuously deforming an elongated workpiece of indefinite length to produce an elongated product of indefinite length, said apparatus comprising:*

a. a deforming agency;

b. a train of gripping elements;

c. first means providing an endless path for said train of gripping elements, said path including a first station upstream of said deforming agency and a second station downstream of said deforming agency;

d. second means for continuously moving said train of gripping elements around said endless path, the direction of travel of said train of gripping elements being from said first station toward said second station;

e. third means for continuously advancing said elongated workpiece against said deforming agency to produce elongated product, said third means comprising means for placing said moving train of gripping elements between said first station and said deforming agency in continuous operative engagement with the elongated surface of said elongated workpiece, thereby to continuously apply motive force along the elongated surface of said elongated workpiece in the direction of said deforming agency, said third means further comprising means for continuously applying pressure on those surfaces of said gripping elements remote from the elongated surface of said elongated workpiece between said first station and said deforming agency whereby to maintain normal stress in said elongated workpiece of magnitude such that the difference between axial stress and normal stress in said elongated workpiece at any point between said first station and the entrance to said deforming agency does not exceed the yield strength of the workpiece material.

39. [Apparatus as in claim **36,** wherein:

f. said third means is adapted to continuously apply] *Apparatus for continuously deforming an elongated workpiece of indefinite length to produce an elongated product of indefinite length, said apparatus comprising:*

a. a deforming agency;

b. a train of gripping elements;

c. first means providing an endless path for said train of gripping elements, said path including a first station upstream of said deforming agency and a second station downstream of said deforming agency;

d. second means for continuously moving said train of gripping elements around said endless path, the direction of travel of said train of gripping elements being from said first station toward said second station;

e. third means for continuously advancing said elongated workpiece against said deforming agency to produce elongated product, said third means comprising means for placing said moving train of gripping elements between said first station and said deforming agency in continuous operative engagement with the elongated surface of said elongated workpiece, thereby to continuously apply motive force along the elongated surface of said elongated workpiece in the direction of said deforming agency, said third means further comprising means for continuously applying a pressure gradient on those surface of said gripping elements remote from the elongated surface of said elongated workpiece between said first station and said deforming agency, said pressure gradient increasing from said first station toward said deforming agency, whereby to maintain a normal stress gradient in said elongated workpiece increasing from said first station toward said deforming agency and of magnitude such that

at any point between said first station and the entrance to said deforming agency the difference between axial stress and normal stress in said elongated workpiece does not exceed the yield strength of the workpiece material.

40. Apparatus for continuously deforming an elongated workpiece of indefinite length to produce an elongated product of indefinite length, said apparatus comprising:

a. a deforming agency;

b. a plurality of trains of gripping elements;

c. a plurality of first means, each of said first means being operatively associated with one train of gripping elements and providing an endless path for said train of gripping elements;

d. a plurality of second means, each of said second means being operatively associated with one train of gripping elements and being adapted to continuously move said train of gripping elements around its respective endless path past a first station upstream of said deforming agency toward a second station downstream of said deforming agency, the first and second stations and the span therebetween being common to all of said plurality of endless paths;

e. the gripping elements in each of said pluarlity of moving trains of gripping elements being [adapted] *configured* to cooperate with each other to form an endless centrally apertured chamber extending between and moving from said first station to said second station;

f. the moving endless chamber receiving the elongated workpiece in the central aperture thereof and being [adapted to] *configured to continuously advance said elongated workpiece against said deforming agency and produce elongated product by* continuously [operative engage] *operatively engaging the entire perimeter of the elongated surface of the elongated workpiece* [thereby] *for* to continuously [apply] *applying* motive force along the entire perimeter of the elongated surface of the elongated workpiece in the direction of the deforming [agency, whereby to continuously advance said elongated workpiece against said deforming agency and produce elongated product.] *agency.*

41. Apparatus as in claim **40**, wherein

g. the moving endless chamber is [adapted] *configured* to cumulate motive force from said first station toward said deforming agency whereby to produce [an axial] *a compressive* stress gradient within said elongated workpiece increasing from said first station toward said deforming agency.

42. Apparatus as in claim **40**, further comprising:

g. third means [adapted to] *for* continuously [apply] *applying* external pressure on and around the entire perimeter of the endless chamber from said first station to said deforming agency whereby to maintain normal stress in the elongated workpiece between the first station and the deforming agency of magnitude such that at any point between the entrance to said deforming agency and said first station the difference between axial stress and normal stress in said elongated workpiece does not exceed the yield strength of the workpiece material.

43. Apparatus as in claim **41**, further comprising:

h. third means [adapted to] *for* continuously [apply] *applying* an external pressure gradient on and around the entire perimeter of the endless chamber from said first station to said deforming agency, said pressure gradient increasing from said first station toward said deforming agency whereby to maintain a normal stress gradient in said elongated workpiece increasing from said first station toward said deforming agency of magnitude such that at any point between the entrance to said deforming agency and said first station the difference between axial stress and normal stress in said elongated workpiece does not exceed the yield strength of the workpiece material.

44. Apparatus for continuously deforming an elongated workpiece to produce an elongated product, said apparatus comprising:

a. a deforming agency;

b. first means for applying a coating of shear transmitting medium to the elongated surface of said elongated workpiece;

c. second means between said deforming agency and said first means for continuously applying motive force in the direction of said deforming agency along that surface of said coating of shear transmitting medium remote from the elongated surface of said elongated workpiece thereby to exert drag force along the elongated surface of said elongated workpiece in the direction of said deforming agency and continuously advance said elongated workpiece against said deforming agency to produce elongated product.

45. Apparatus as in claim **44,** wherein:

d. said first means is adapted to apply said coating of shear transmitting medium to the entire perimeter of the elongated surface of said elongated workpiece.

46. Apparatus as in claim **45,** wherein:

e. said second means is adapted to apply motive force around the entire perimeter of said coating of shear transmitting medium.

47. Apparatus as in claim **44,** wherein:

d. said first means is adapted to continuously apply said coating of shear transmitting medium around the entire perimeter of the elongated surface of the elongated workpiece as the elongated workpiece moves past said first means toward said second means.

48. Apparatus as in claim **47,** wherein:

e. said second means is adapted to apply motive force around the entire perimeter of said coating of shear transmitting medium.

49. Apparatus as in claim **44,** wherein:

d. said shear transmitting medium is a viscous fluid.

50. Apparatus as in claim **49,** wherein:

e. said viscous fluid is beeswax.

51. Apparatus as in claim **49,** wherein:

e. said viscous fluid is polyethylene wax.

52. Apparatus as in claim **44,** further comprising:

d. third means to continuously apply pressure on that surface of said coating of shear transmitting medium remote from the elongated surface of said elongated workpiece between said deforming agency and said first means to maintain normal stress in said elongated workpiece of magnitude such that at any point between the entrance to said deforming agency and said first means the difference between axial stress and normal stress in said

elongated workpiece does not exceed the yield strength of the workpiece material.

53. Apparatus for continuously deforming an elongated workpiece to produce an elongated product, said apparatus comprising:

a. a deforming agency;

b. first means for applying a coating of shear transmitting medium to the elongated surface of said elongated workpiece;

c. second means between said deforming agency and said first means for continuously applying motive force in the direction of said deforming agency from a first station upstream of said deforming agency to said deforming agency along that surface of said coating of shear transmitting medium remote from the elongated surface of said elongated workpiece, said second means being adapted to cumulate said motive force from said first station toward said deforming agency thereby to exert drag force along the elongated surface of said elongated workpiece in the direction of said deforming agency which drag force increases from said first station toward said deforming agency, and thus to advance said elongated workpiece against said deforming agency to produce elongated product.

54. Apparatus as in claim **53,** wherein:

d. said first means is adapted to apply said coating of shear transmitting medium to the entire perimeter of the elongated surface of said elongated workpiece.

55. Apparatus as in claim **54,** wherein:

e. said second means is adapted to apply motive force around the entire perimeter of said coating of shear transmitting medium.

56. Apparatus as in claim **53,** wherein:

d. said first means is adapted to continuously apply said coating of shear transmitting medium around the entire perimeter of the elongated surface of the elongated workpiece as the elongated workpiece moves past said first means toward said second means.

57. Apparatus as in claim **56,** wherein:

e. said second means is adapted to apply motive force around the entire perimeter of said coating of shear transmitting medium.

58. Apparatus as in claim **53,** wherein:

d. said shear transmitting medium is a viscous fluid.

59. Apparatus as in claim **58,** wherein:

d. said viscous fluid is beeswax.

60. Apparatus as in claim **58,** wherein:

d. said viscous fluid is polyethylene wax.

61. Apparatus as in claim **53,** further comprising:

d. third means to continuously apply a pressure gradient on that surface of said coating of shear transmitting medium remote from the elongated surface of said elongated workpiece between said first station and said deforming agency and increasing from said first station toward said deforming agency to maintain a normal stress gradient in said elongated workpiece increasing from said first station toward said deforming agency and of magnitude such that at any point between said first station and the entrance to said deforming agency the difference between axial stress and normal stress in said elongated workpiece does not exceed the yield strength of the workpiece material.

62. Apparatus for continuously deforming an elongated workpiece of indefinite length to produce an elongated product of indefinite length, said apparatus comprising:

a. a deforming agency;

b. first means for applying a coating of shear transmitting medium to the entire perimeter of the elongated surface of said elongated workpiece;

c. an endless chamber between said deforming agency and said first means, said endless chamber being adapted to encircle and contact that surface of said coating of shear transmitting medium remote from the elongated surface of said elongated workpiece;

d. second means to continuously advance said endless chamber from a first station upstream of said deforming agency to a second station downstream of said deforming agency thereby to continuously apply motive force in the direction of said deforming agency along said surface of said coating and thereby exert drag force along the elongated surface of said elongated workpiece in the direction of said deforming agency and continuously advance said elongated workpiece against said deforming agency to produce elongated product.

63. Apparatus as in claim **62,** wherein:

e. said first means is adapted to continuously apply said coating of shear transmitting medium around the entire perimeter of the elongated surface of said elongated workpiece at a third station upstream of said first station as said elongated workpiece moves past said third station toward said first station.

64. Apparatus as in claim **62,** wherein:

e. said shear transmitting medium is a viscous fluid.

65. Apparatus as in claim **64,** wherein:

f. said viscous fluid is beeswax.

66. Apparatus as in claim **64,** wherein:

f. said viscous fluid is polyethylene wax.

67. Apparatus as in claim **62,** further comprising:

e. third means to continuously apply external pressure on and around the entire perimeter of said endless chamber from said first station to said deforming agency sufficient to maintain normal stress in said elongated workpiece of magnitude such that the difference between axial stress and normal stress in the elongated workpiece between said first station and the entrance to said deforming agency does not exceed the yield strength of the workpiece material.

68. Apparatus as in claim **62,** further comprising:

e. third means to continuously apply an external pressure gradient on and around the entire perimeter of said endless chamber increasing from said first station toward said deforming agency, said external pressure gradient maintaining a normal stress gradient in said elongated workpiece increasing from said first station toward said deforming agency and of magnitude such that at any point between said first station and the entrance to said deforming agency the difference between axial stress and normal stress in the elongated workpiece does not exceed the yield strength of the workpiece material.

69. Apparatus as in claim **62,** wherein:

e. said endless chamber comprises:

i. a plurality of trains of gripping elements,

ii. a plurality of third means, each of said third means being operatively associated with one of said trains of gripping elements and providing an

endless path for said train of gripping elements,

iii. said first station and second station and the span therebetween being common to all of said plurality of endless paths,

iv. gripping elements from all of said trains being adapted to cooperate to form said endless chamber at said first station and being further adapted to continue such cooperation along said span.

70. Apparatus as in claim **62,** wherein:

e. said endless chamber comprises:

i. a plurality of trains of gripping elements,

ii. a plurality of third means, each of said third means being operatively associated with one of said trains of gripping elements and providing an endless path for said train of gripping elements,

iii. said first station and second station and the span therebetween being common to all of said plurality of endless paths,

iv. said gripping elements being further adapted to discontinue such cooperation at said second station.

71. Apparatus as in claim **62,** wherein:

g. said endless chamber is adapted to slidably sealingly engage the external surface of said deforming agency in moving from said first relation to said second station.

72. Apparatus as in claim **67,** wherein:

f. said third means comprises:

i. a cylinder having a central aperture receiving said endless chamber,

ii. fourth means to maintain fluid pressure in said central aperture between said cylinder and the external surface of said endless chamber.

73. Apparatus as in claim **68,** wherein:

f. said third means comprises:

i. a cylinder having a central aperture receiving said endless chamber,

ii. spaced sealing means interposed between said cylinder and the external surface of said endless chamber along said central aperture and dividing said central aperture into a plurality of pressure chambers,

iii. fourth means to introduce pressurized fluid into that endmost pressure chamber adjacent said deforming agency,

iv. a plurality of pressure reducing valves, each pressure reducing valve being operatively interposed between adjacent pressure chambers, the pressure reducing valves being arranged to provide decreasing fluid pressure in the plurality of pressure chambers toward the upstream end of said cylinder.

74. Method for continuously deforming an elongated workpiece of indefinite length to produce an elongated product of indefinite length, said method comprising:

continuously moving from a first station upstream of a deforming agency around said deforming agency to a second station downstream of said deforming agency a train of gripping elements encircling said elongated workpiece and in operative engagement with the entire perimeter of said elongated workpiece from said first station to said deforming agency, thereby to continuously apply motive force along the said perimeter of said elongated workpiece in the direction of said deforming agency whereby to continuously advance said elongated workpiece against said deforming agency to produce elongated product.

75. Method for continuously deforming an elongated workpiece of indefinite length to produce an elongated product of indefinite length, said method comprising:

a. applying a coating of shear transmitting medium to the entire perimeter of the elongated surface of said elongated workpiece at a first station upstream of a deforming agency;

b. continuously moving from a second station between said deforming agency and said first station around and slidably sealingly engaging the perimeter of said deforming agency to a third station downstream of said deforming agency a train of gripping elements encircling said elongated workpiece and in operative engagement with the entire perimeter of that surface of said coating of shear transmitting medium remote from the elongated surface of said elongated workpiece from said second station to said deforming agency thereby to apply motive force to said surface of said coating of shear transmitting medium and drag force along the elongated surface of said elongated workpiece from said second station to said deforming agency;

c. whereby to continuously advance said elongated workpiece and said coating of shear transmitting medium through said deforming agency to produce elongated product.

76. Apparatus for continuously deforming an elongated workpiece of indefinite length to produce an elongated product of indefinite length, said apparatus comprising:

a. a deforming agency,

b. a train of gripping elements adapted to encircle said elongated workpiece and further adapted to operatively engage the entire perimeter of said elongated workpiece from a first station upstream of said deforming agency to said deforming agency,

c. means [to continuously move] *for continuously advancing said elongated workpiece against said deforming agency to produce elongated product by continuously moving* said train of gripping elements from said first station around said deforming agency to a second station downstream of said deforming [agency,

d. thereby] *agency so as* to continuously apply motive force along the said perimeter of said elongated workpiece in [the direction of said deforming agency whereby to continuously advance said elongated workpiece against said deforming agency to produce elongated product.] *the direction of said deforming agency.*

77. Apparatus as in claim **76,** wherein:

d. said train of gripping elements is endless.

78. Apparatus for continuously deforming an elongated workpiece of indefinite length to produce an elongated product of indefinite length, said apparatus comprising:

a. a deforming agency,

b. first means adapted to apply a coating of shear transmitting medium to the entire perimeter of the elongated surface of said elongated workpiece at a first station upstream of said deforming agency,

c. a train of gripping elements adapted to encircle said elongated workpiece and adapted to operatively engage the entire perimeter of that surface of said coating of shear transmitting medium remote from the elongated surface of said elongated workpiece from a second station between said deforming agency and said first station to said deforming

agency, said train of gripping elements being further adapted to slidably sealingly engage the perimeter of said deforming agency,

d. second means to continuously move said train of gripping elements from said second station past said deforming agency in sliding sealing engagement with the perimeter thereof to a third station downstream of said deforming agency,

e. thereby to apply motive force to said surface of said coating of shear transmitting medium and drag force along the elongated surface of said elongated workpiece from said second station to said deforming agency,

f. whereby to continuously advance said elongated workpiece and said coating of shear transmitting medium through said deforming agency to produce elongated product.

79. Apparatus as in claim **78,** wherein:

g. said train of gripping elements is endless.

80. Apparatus as in claim **78,** wherein:

g. said shear transmitting medium is a viscous fluid.

81. Apparatus as in claim **80,** wherein:

h. said viscous fluid is beeswax.

82. Apparatus as in claim **80,** wherein:

h. said viscous fluid is polyethylene wax.

83. Method for continuously deforming an elongated workpiece of indefinite length to produce an elongated product of indefinite length, said method comprising:

a. continuously moving a motive means around an endless path, said path including a first station upstream of a deforming agency and a second station downstream of said deforming agency, the direction of travel of said motive means around said endless path being from said first station toward said second station;

b. continuously placing successive portions of said motive means between said first station and said deforming agency in operative engagement with the elongated surface of said elongated workpiece thereby to continuously apply motive force along the elongated surface of said elongated workpiece in the direction of said deforming agency;

c. continuously advancing said elongated workpiece against said deforming agency by means of said motive force to produce elongated product.

84. Method for continuously deforming an elongated workpiece of indefinite length to produce an elongated product of indefinite length, said method comprising:

a. continuously moving a motive means around an endless path, said path including a first station upstream of a deforming agency and a second station downstream of said deforming agency, the direction of travel of said motive means around said endless path being from said first station toward said second station;

b. continuously placing successive portions of said motive means between said first station and said deforming agency in operative engagement with the elongated surface of said elongated workpiece thereby to continuously apply motive force along the elongated surface of said elongated workpiece in the direction of said deforming agency; while simultaneously

c. cumulating said motive force from said first station toward said deforming agency whereby to produce a compressive stress gradient within said elongated workpiece increasing from said first station toward said deforming agency and

d. continuously advancing said elongated workpiece against said deforming agency by means of said motive force to produce elongated product.

85. Method for continuously deforming an elongated workpiece of indefinite length to produce an elongated product of indefinite length, said method comprising:

a. continuously moving a motive means around an endless path, said path including a first station upstream of a deforming agency and a second station downstream of said deforming agency, the direction of travel of said motive means around said endless path being from said first station toward said second station;

b. continuously placing successive portions of said motive means between said first station and said deforming agency in operative engagement with the elongated surface of said elongated workpiece thereby to continuously apply motive force along the elongated surface of said elongated workpiece in the direction of said deforming agency; while simultaneously

c. continuously applying pressure on that surface of said motive means remote from the elongated surface of said elongated workpiece between said first station and said deforming agency whereby to maintain normal stress in said elongated workpiece of magnitude such that the difference between axial stress and normal stress in said elongated workpiece at any point between said first station and the entrance to said deforming agency does not exceed the yield strength of the workpiece material and

d. continuously advancing said elongated workpiece against said deforming agency be means of said motive force to produce elongated product.

86. Method as in claim 84, further comprising:

e. simultaneously with steps (b) and (c), continuously applying pressure on that surface of said motive means remote from the elongated surface of said elongated workpiece between said first station and said deforming agency, whereby to maintain a normal stress gradient in said elongated workpiece increasing from said first station toward said deforming agency and of magnitude such that at any point between said first station and the entrance to said deforming agency the difference between axial stress and normal stress in said elongated workpiece does not exceed the yield strength of the workpiece material.

87. Method for continuously deforming an elongated workpiece of indefinite length to produce an elongated product of indefinite length, said method comprising:

a. continuously moving an endless surface around an endless path including a first station upstream of a deforming agency and a second station downstream of said deforming agency in such manner that successive portions of said endless surface between said first station and said deforming agency provide a chamber continuously advancing from said first station toward said deforming agency,

b. placing the interior of said chamber in continuous operative engagement with the surface of said elongated workpiece from said first station to said deforming agency thereby to continuously apply motive force along said surface in the direction of said deforming agency,

c. continuously advancing said elongated workpiece against said deforming agency by means of said motive force against said deforming agency to produce

elongated product.

88. Method for continuously deforming an elongated workpiece of indefinite length to produce an elongated product of indefinite length, said method comprising:

a. continuously moving an endless surface around an endless path including a first station upstream of a deforming agency and a second station downstream of said deforming agency in such manner that successive portions of said endless surface between said first station and said deforming agency provide a chamber continuously advancing from said first station toward said deforming agency,

b. placing the interior of said chamber in continuous operative engagement with the surface of said elongated workpiece from said first station to said deforming agency thereby to continuously apply motive force along said surface in the direction of said deforming agency, while simultaneously

c. cumulating said motive force from said first station toward said deforming agency whereby to produce a compressive stress gradient within said elongated workpiece increasing from said first station toward said deforming agency and

d. continuously advancing said elongated workpiece by means of said motive force against said deforming agency to produce elongated product.

89. Method for continuously deforming an elongated workpiece of indefinite length to produce an elongated product of indefinite length, said method comprising:

a. continuously moving an endless surface around an endless path including a first station upstream of a deforming agency and a second station downstream of said deforming agency in such manner that successive portions of said endless surface between said first station and said deforming agency provide a chamber continuously advancing from said first station toward said deforming agency,

b. placing the interior of said chamber in continuous operative engagement with the surface of said elongated workpiece from said first station to said deforming agency thereby to continuously apply motive force along said surface in the direction of said deforming agency, while simultaneously

c. continuously applying external pressure on the perimeter of said chamber from said first station to said deforming agency, said external pressure having sufficient magnitude to maintain normal stress in the elongated workpiece of magnitude such that the difference between axial stress and normal stress in the elongated workpiece at any point between said first station and the entrance to said deforming agency does not exceed the yield strength of the workpiece material and

d. continuously advancing said elongated workpiece by means of said motive force against said deforming agency to produce elongated product.

90. Method as in claim 88, further comprising:

d. simultaneously with steps (b) and (c), continuously applying an external pressure gradient between said first station and said deforming agency on the perimeter of said chamber increasing from said first station toward said deforming agency, said external pressure gradient maintaining a normal stress gradient in said elongated workpiece increasing from said first station toward said deforming agency and of magnitude such that at any point between said first station and the entrance to said deforming agency the difference between axial stress and normal stress in the elongated workpiece does not exceed the yield strength of the workpiece material.

91. Apparatus for continuously deforming an elongated workpiece of indefinite length to produce an elongated product of indefinite length, said apparatus comprising:

a. a deforming agency;

b. motive means;

c. first means providing an endless path for said motive means, said path including a first station upstream of said deforming agency and a second station downstream of said deforming agency;

d. second means for continuously moving said motive means around said endless path, the direction of travel of said motive means being from said first station toward said second station;

e. third means for continuously advancing said elongated workpiece against said deforming agency to produce elongated product, said third means comprising means for placing said moving motive means between said first station and said deforming agency in continuous operative engagement with the elongated surface of said elongated workpiece, thereby to continuously apply motive force along the elongated surface of said elongated workpiece in the direction of said deforming agency.

92. Apparatus for continuously deforming an elongated workpiece of indefinite length to produce an elongated product of indefinite length, said apparatus comprising:

a. a deforming agency;

b. motive means;

c. first means providing an endless path for said motive means, said path including a first station upstream of said deforming agency and a second station downstream of said deforming agency;

d. second means for continuously moving said motive means around said endless path, the direction of travel of said motive means being from said first station toward said second station;

e. third means for continuously advancing said elongated workpiece against said deforming agency to produce elongated product, said third means comprising means for placing said moving motive means between said first station and said deforming agency in continuous operative engagement with the elongated surface of said elongated workpiece, thereby to continuously apply motive force along the elongated surface of said elongated workpiece in the direction of said deforming agency, said third means further comprising means for cumulating motive force from said first station toward said deforming agency whereby to produce a compressive stress gradient within said elongated workpiece increasing from said first station toward said deforming agency.

93. Apparatus for continuously deforming an elongated workpiece of indefinite length to produce an elongated product of indefinite length, said apparatus comprising:

a. a deforming agency;

b. motive means;

c. first means providing an endless path for said motive means, said path including a first station upstream of said deforming agency and a second station downstream of said deforming agency;

d. second means for continuously moving said motive means around said endless path, the direction of travel of said motive means being from said first

station toward said second station;

e. third means for continuously advancing said elongated workpiece against said deforming agency to produce elongated product, said third means comprising means for placing said moving motive means between said first station and said deforming agency in continuous operative engagement with the elongated surface of said elongated workpiece, thereby to continuously apply motive force along the elongated surface of said elongated workpiece in the direction of said deforming agency, said third means further comprising means for continuously applying pressure on that surface of said motive means remote from the elongated surface of said elongated workpiece between said first station and said deforming agency whereby to maintain normal stress in said elongated workpiece of magnitude such that the difference between axial stress and normal stress in said elongated workpiece at any point between said first station and the entrance to said deforming agency does not exceed the yield strength of the workpiece material.

94. Apparatus for continuously deforming an elongated workpiece of indefinite length to produce an elongated product of indefinite length, said apparatus comprising:

a deforming agency;

b. motive means;

c. first means providing an endless path for said motive means, said path including a first station upstream of said deforming agency and a second station downstream of said deforming agency;

d. second means for continuously moving said motive means around said endless path, the direction of travel of said motive means being from said first station toward said second station;

e. third means for continuously advancing said elongated workpiece against said deforming agency to produce elongated product, said third means comprising means for placing said moving motive means between said first station and said deforming agency in continuous operative engagement with the elongated surface of said elongated workpiece, thereby to continuously apply motive force along the elongated surface of said elongated workpiece in the direction of said deforming agency, said third means further comprising means for continuously applying a pressure gradient on that surface of said motive means

remote from the elongated surface of said elongated workpiece between said first station and said deforming agency, said pressure gradient increasing from said first station toward said deforming agency, whereby to maintain a normal stress gradient in said elongated workpiece increasing from said first station toward said deforming agency and of magnitude such that at any point between said first station and the entrance to said deforming agency the difference between axial stress and normal stress in said elongated workpiece does not exceed the yield strength of the workpiece material.

95. Method for continuously deforming an elongated workpiece of indefinite length to produce an elongated product of indefinite length, said method comprising:

continuously moving from a first station upstream of a deforming agency around said deforming agency to a second station downstream of said deforming agency motive means in operative engagement with the surface of said elongated workpiece from said first station to said deforming agency, thereby to continuously apply motive force along the said surface of said elongated workpiece in the direction of said deforming agency whereby to continuously advance said elongated workpiece against said deforming agency to produce elongated product.

96. Apparatus for continuously deforming an elongated workpiece of indefinite length to produce an elongated product of indefinite length, said apparatus comprising:

a. a deforming agency,

b. motive means for operatively engaging the surface of said elongated workpiece from a first station upstream of said deforming agency to said deforming agency,

c. means for continuously advancing said elongated workpiece against said deforming agency to produce elongated product, said means comprising means for continuously moving said motive means from said first station around said deforming agency to a second station downstream of said deforming agency so as to continuously apply motive force along the said surface of said elongated workpiece in the direction of said deforming agency.

97. Apparatus as in claim 96, wherein:

d. said motive means is endless.

* * * * *

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. RE 28,795 **Dated** May 4, 1976

Inventor(s) FRANCIS JOSEPH FUCHS, JR.

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

In the specification, column 6, line 51, "guadrants" should read --quadrants--. Column 9, line 63, "effort" should read --effect--. Column 10, line 10, "are" should read --art--; line 25, "normal" should read --nominal--; line 64, "production" should read --product--.

In the claims, claim 1, column 10, line 67, "of" should read --for--. Column 11, claim 2, line 39, "same" should read --said--; same claim, line 43, "[agency]" should read --[agency.]. Column 12, claim 4,

line 23, "suchc" should read --such--; claim 6, lines 59-60, "conti-nously" should read --continuously--. Column 14, claim 11, line 19, "," should read --;--. Column 17, claim 37, line 36, "frist" should read --first--. Column 18, claim 39, line 61, "surface" should read --surfaces--. Column 19, claim 40, lines 39-40, "the entire perimeter of the elongated surface of the elongated workpiece" should not be in italics; same claim, line 40, "to" should read --[to]--; claim 41, line 48, "wherein" should read --wherein:--. Column 23, claim 71, line 25, "relation" should read --station--. Column 25, claim 84, line 68, "and" should read --; and--. Column 26, claim 85, line 31, "and" should read --; and--; claim 87, line 68, "force against said deforming agency" should read --force--. Column 27, claim 88, line 23, "and" should read --; and--; claim 89, line 53, "and" should read --; and--. Column 29, claim 94, line 27, "a deforming" should read --a. a deforming--.

Signed and Sealed this

Twenty-eighth Day of December 1976

[SEAL]

Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents and Trademarks